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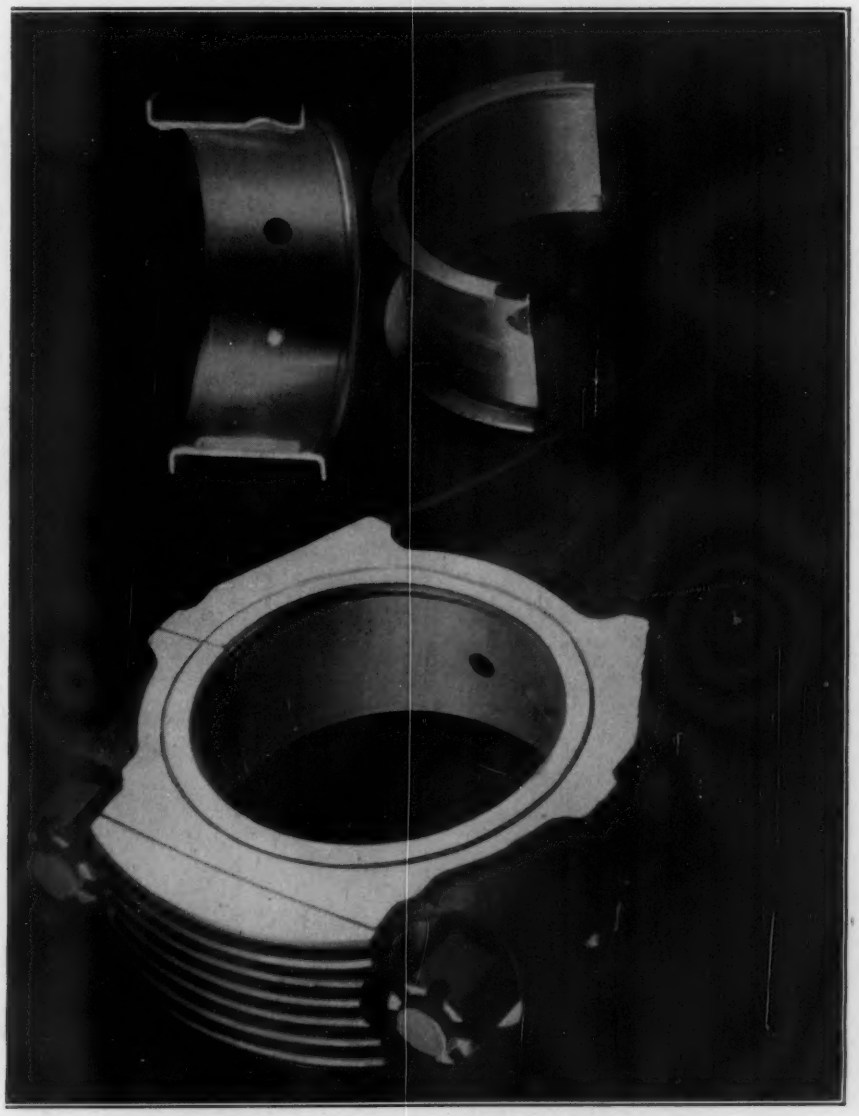
THE TECH ENGINEERING NEWS



IN THIS ISSUE

Cyanamid

A Future In Foods

London Transport System

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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OUR AUTHORS

LOUIS MARSHALL was requested by the TECH ENGINEERING NEWS to write an article that would give students of chemistry an insight on the possibilities in Government service. The article he has written is entitled *The Young Chemist*. Mr. Marshall, well under thirty, was born and has spent most of his life in New York City. Shortly after his graduation from the City College of New York in 1930,he was sent to the United States Navy Yard at Newport News, Virginia, where he was entrusted the delicate task of analyzing steels in various stages of composition. In 1933 he was transferred to the Brooklyn Navy Yard where he is now serving as a qualified Assistant Chemist.

PROFESSOR BERNARD E. PROCTOR, who wrote the article entitled *A Future in Foods*, is an Assistant Professor in Option II of Course VII, which is concerned with Food Technology and Industrial Fermentations. He received the S.B. degree from the Massachusetts Institute of Technology in 1923 and the Ph.D. in 1927. He is a member of Sigma Xi and Delta Omega, the American Chemical Society, the Society of American Bacteriologists, and a Fellow of the American Public Health Association. Since 1935 he has been Chairman of the Committee on Foods of the Food and Nutrition Section of the American Public Health Association.

This June, Dr. Proctor is attending the International Congress of Refrigeration at The Hague in Holland as official delegate from the Institute. At that meeting he is to present a joint paper with Dean Prescott entitled "Modern Progress in the Application of Refrigeration to Public Health."

MARC CUTLER, '39, author of the article on *Bakelite*, was graduated from Brookline High School in 1934. He is a member of Sigma Alpha Mu fraternity. Most of his extra-curricula time is spent at work on the TECH ENGINEERING NEWS, although he aided in the Freshman Hobby Exhibit, where he displayed a homemade photographic enlarger. His pet diversions are photography and physics; his favorite sports are tennis, riding, and swimming. He is member of Course VIII, Option 2, and hopes some day to do research work for a large industrial company.

DR. WALTER S. LANDIS, Vice-President and a director of the American Cyanamid Company, is the author of the article on *The Present Status of Cyanamid Industry*. Dr. Landis was graduated from Lehigh University in 1902 with the B.S. degree. After two years as an assistant in metallurgy at Lehigh he studied abroad. He received the M.S. degree from Lehigh in 1906; after several years on the instructing staff of Lehigh University, as an Instructor, Assistant Professor, and Associate Professor, Dr. Landis joined the American Cyanamid Company as Chief Technologist. He held this position from 1912 until he was made a Vice-President of the company in 1922. This same year he was granted the honorary degree of Sc.D. from Lehigh University. Dr. Landis is a past President of the American Institute of Metallurgical Engineers and of the American Electro-Chemical Society. He is a member of the American Institute of Chemical Engineers and of the American Chemical Society. At present he holds the position of President of Fumigators Supply Company. Dr. Landis is a member of Phi Sigma Kappa fraternity. His status is that of an executive engineer, while his fields include nitrogen fixation, fertilizers, and electric furnace products.

EDITOR'S NOTE: The article telling the story of *London Transportation* was written by a person very closely connected with its operation. However, because of his official capacity, he did not wish to pen his signature to the article.

BRAIN TWISTERS

BELOW are two mathematical recreations of such a nature that the average Tech man should be able to solve them with little difficulty.

In the century and a half between 1725 and 1875 the French fought and won a certain battle on April 22nd of one year, and 4382 days later, also on April 22nd, they gained another victory. The sum of the digits of the years is 40. Find the dates of the battles.

A class of digit problems depends on finding the values of certain symbols which represent specified numbers. In an example of this type the object is to find the digits represented by letters in the following sum:

```
ab)cdeeb(bfb
  ceb
  ---
  gge
  gch
  ---
  ceb
  ceb
```

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE TECH ENGINEERING NEWS

JUNE, 1936
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Technique

DUSK

Technical Progress Promises

A FUTURE IN FOODS

For the Graduate Engineer

By BERNARD E. PROCTOR
Assistant Professor, Department of Biology and Public Health, Massachusetts Institute of Technology

THE technically trained student about to graduate from scientific and engineering schools must eventually consider the opportunities which are available for the best utilization of his knowledge and his energies—not perhaps so much from the standpoint of how he may obtain *a* job, as fortunately economic conditions have improved beyond that stage today, but rather how he may enter fields of endeavor in which his services and capabilities will be of most value both to himself and his employers as time goes on.

A survey of the positions held by the graduates of any scientific or engineering school would show a wide and very likely surprising divergence of occupations successfully filled. Some of these positions, especially those held by the older age groups, would doubtless be administrative and executive in character; others, in special fields of engineering, architecture, chemistry, physics, and allied sciences, and a number in teaching, sales, law, medicine, journalism, and perhaps even in the clergy.

Outstanding as undoubtedly many graduates on such a list would be, the problem of the man with his sheepskin in hand (or within reach) is not solved by reading where others are or just what they have done. It is his problem to see what *his* assets are, evaluate their worth in terms of usefulness to others, and having determined where his talents might be of greatest value, make an effort to have them utilized in that manner. By assets one does not imply financial resources, because seniors of recent years are likely to be *sans l'argent*. The technical knowledge gained by his professional training, backed by the personal qualities acquired either by inheritance, environment, or self-development, comprise the assets of the embryonic technically trained man. The term *embryonic* is used advisedly, because the fertile seed represented by the recent graduate now needs the proper soil in which to sprout, fix his roots, emerge into the sunlight and eventually flower and bear fruit.

The fields of industry where graduates from scientific schools may sow their seeds are legion, dependent on one's professional training, his likes and dislikes, his inherent abilities, and his ability to work with, under, or over others. The intention of this discussion is to present some of the aspects of one fertile field of service for technically trained professional men, namely, the food industries.

Government experts in the Foodstuffs Division of the Department of Commerce estimate that the average annual per capita expenditure for foods is approximately $178 and this figure applied during a severe financial depression. Assuming the accuracy of this estimate, with some 125 million people in the United States, the annual food expenditures amount to over 22 billion dollars. A considerable portion of such sums goes to those who raise the raw materials, but the transportation, manufacture, packaging, refrigeration, canning, and distribution of finished products add large increments to the raw material costs. Much of this increment, amounting to some billions of dollars, is spent for processing services and an increasing proportion is being expended for technical services.

In the long and devious paths and processes which our major food supplies follow from their sources to the American table, there are many places where technical and scientific advice and practice are essential.

Chemists are needed to evolve better soil fertilizers and produce them; also, to produce better insecticides and fungicides to protect the crops and food animals. Physicists have shown their ability to stimulate or retard seed development by irradiation. The biologist produces better crop plants and must know the optimum conditions for plant and animal metabolism. The engineer evolves and produces planting and harvesting machinery, furnishes hydro-electric power and irrigation systems, water-supplies, roads, transportation equipment in the form of trains, ships, trucks, and tractors. The meteorologist by his forecast predicts the coming of frosts, storms, and floods, which predictions have often saved crops and sometimes the growers. Some technical graduates find themselves in the service of the nation's food supply in capacities similar to those mentioned above.

More numerous possibilities are available for the service of scientific and technical personnel in those numberless industries which fabricate the raw materials of our food-supply from the wheat and corn fields, the cane and beet-sugar plantations, abattoirs, the fisheries, fruit orchards and citrus groves, vineyards, truck-gardens, coconut and coffee plantations, and the many other sources of foods from many lands.

In the food industries themselves—where the cane and beets become sugar and molasses; the hog becomes pork, bacon, lard, and sausage; milk becomes butter, ice-cream, cheese or casein; wheat becomes flour, bread, or pretzels; corn becomes starch, glucose, or salad oil—are the potential *futures in foods* of many technically trained men.

In the 1935 year-book of one large food-packing organization, the total current assets of which were listed therein at over 185 million dollars, the statement was made that this organization maintains the world's largest and most complete industrial food laboratory. Such organizations as this one know they need technical men and have them throughout their organization. Perhaps such policies tend to explain their success.

Many food organizations have yet to learn that the application of science and engineering in their industry may change red ink to black. Not a few have closed their doors and been picked up on the auction block by competitors who are equipped with staffs that use scientific precision methods and planning, thereby keeping up with the times. The food industries have changed their products and the methods have changed accordingly. In general the methods have become more systematized, more automatic, more technical, and more scientific—hence the need of the technical man.

About fifty years ago the public became familiar with staple foods in cans, although quality was low and their distribution was negligible compared with the present. Next, milk came in individual bottles. The unit package of breakfast foods and cookies came soon thereafter; butter, bread, and cheese followed. The prepared foods have extended from biscuit-mixes and sliced bread to canned hash, caviar, and cooked whole potatoes. One of the newest and largest volume food by-products sold today, canned dog and cat food, was laughed at when proposed just a few years back.

The home-baked bread of pre-war days is now a curiosity

and lard is almost unknown to many modern housewives who have been educated in the use of hydrogenated solidified vegetable oils. The use of cellophane, light-proof parchments, and similar wrapping materials, vacuum containers for coffee, nuts, and powdered milk have each come about for definite reasons and as the result of technological progress through scientific research. The frozen food industry is in its infancy yet but there is reason to believe that the butcher shop of today may in time be as rare as the red shirt of the old hand-pump fireman days.

Such developments have inaugurated new food industries and widened the whole field of possibilities for the technically trained man.

The question arises, however, to the student about to start his professional or industrial future, where can they use me and my training? There is no one answer but other men with a scientific training may be found in the canning industry, the dairy industry, the packing industry, large bakeries, ice-cream plants, flour and cocoa mills, beverage plants, fisheries industries, vegetable-oil refineries, sugar refineries, and elsewhere.

The particular technical training the man has experienced will influence the answer as to where, but there are opportunities for every line of scientific training to be helpful in some phases of these industries, if one studies them closely. There are many food companies which need technical men that realize it only when they get such a person. The depression has had its effect on food manufactures as well as other manufactured goods, but people continue to eat when automobiles and fur coats are temporarily in the luxury class.

Some time ago Mr. Clarence Birdseye, the inventor of quick-frozen foods, made the estimate that 77 per cent of all our foods were perishable. The primary cause of all food spoilage and loss is the activities of bacteria and other micro-organisms which attack the so-called perishables.

In addition to the need for mechanical and electrical engineers, refrigeration and air conditioning experts, chemists and chemical engineers, physicists, and other specially trained scientific men, the food industries have developed a distinct need for trained men who have a special knowledge of the fundamental characteristics of foods and who are familiar with the causes of food spoilage, the conditions of food spoilage, and the prevention of such losses.

Such men need biological training primarily because all our foods except salt are at some time in their existence living cells and tissues; but they must also have a thorough knowledge of chemistry, bacteriology, and allied sciences and some appreciation of engineering problems. A knowledge of what constitutes quality in foodstuffs and the technological procedures necessary to attain and preserve quality are essential. The health aspects of foods, the nutritive aspects of foods and their determination, the governmental aspects of foods from a legal standpoint, and the sanitary aspects of food production come into this field of food technology. With increasing distribution of foods in packages, the application and use of cellophane, parchments, fibre, glass, tin, and other containers require for optimum results investigation and test methods from a food standpoint which require special knowledge of the foods under consideration, as well as information concerning the bacteriological, chemical, and physical changes likely to result.

For some years there have been limited numbers of students with this type of training graduating from the Industrial Biology option in Course VII, Biology and Public Health. Last year's group, eight men, were all located in jobs along their professional lines shortly after graduation. Typical older graduates are now holding key positions in both large and small food manufacturing companies, canning and glass packer's research laboratories, beverage plants, confectionery plants, dairy products manufacturers, vitamin laboratories, the quick-freezing industry, governmental food laboratories, and the fermentation industries.

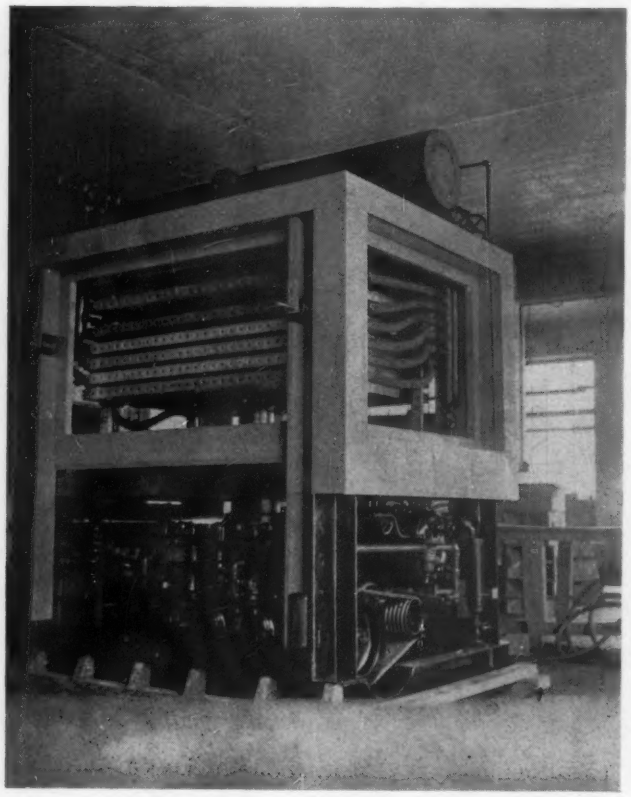
A change in the curriculum for the students in this option scheduled for 1936 makes possible the inclusion of a course in Food Engineering in the fourth year in addition to the required course in Refrigeration which is now taken. The new course, to be given by various members of the staff in Mechanical Engineering, will deal with the mechanical aspects of food processing and handling machinery and equipment, and supplement their experimental work in the food technology laboratories.

An outstanding example of modern food technology is the Birdseye method of quick-freezing foods. Originally developed for the freezing of fish in packages of consumer unit dimensions, its advantages proved so outstanding that its use has spread to the similar quick-freezing of practically every perishable food. Millions of pounds of food are now frozen annually, including such delicate products as oysters, raspberries, green peas, and cream. An illustration of the latest freezer, the Birdseye Plate Froster is shown in Fig 00. Somewhat smaller units of similar design have been mounted on self-contained trucks which may be used in co-operation with cannery organizations to freeze strawberries in Tennessee in June, peas in New Jersey in July, corn in Maine in August, thus assuring these foods at the optimum stage of maturity, and the delicate texture and fine flavors being preserved without loss until they reach the table.

Another far-reaching recent development in food technology is the Rotolactor which enables the milking of 240 cows per hour in the most sanitary milk procuring mechanism ever devised. The cows are led on an automatic circular rotating milking platform, milked mechanically into sterilized glass jars, which are automatically emptied into a recording scale tank, from which the milk is drained and brought to refrigeration temperature inside of five minutes. This mechan-

(*Continued on page 104*)

Refrigerating Engineer



Discussing the Plan of the

LONDON TRANSPORT SYSTEM

—World's Largest Traffic Experiment

Written especially for the Tech Engineering News

MANY visitors come to the headquarters of the London Passenger Transport Board at St. James Park, Westminster. They come to study; and they are studied, not only because they are interesting persons, but also because, by looking through their eyes, it is possible to see new aspects of the immense undertaking which the Board manages.

The German and the Italian wonder how such vast and intricate co-ordination could have been brought about in a country not directed by a dictator. The Russian finds it difficult to comprehend how London Transport can exist in a capitalist state. The Frenchman reflects the unrest of his people by marvelling at the political obstacles which must have been surmounted before so many municipal and private enterprises could be placed under one control.

Visitors from America are interested first in the dimensions of the organisation. When they have studied the magnitude of the work and perhaps have disputed goodhumouredly the claim that the area the Board serves is the largest metropolitan aggregation of population in the world, they express amazement that municipal interests and private interests should have been welded into a public service while yet satisfying the claims of private investors.

It is not easy to understand such things if the enquirer does not possess some knowledge and understanding of the English people, to whom the paradox is orthodox. For, if one examines the history of the movement that led to the amalgamation of 165 separate railway, bus, tram, coach, and trolley-bus undertakings, one feels that the result was inevitable, but also that its achievement is a social and political marvel.

Less than 30 years ago passenger transport in London functioned in such water-tight compartments that it cost 4d. to journey by Underground a distance of a few City blocks from Piccadilly Circus to Bond Street, in the heart of the West End. At Piccadilly Circus the passenger had to pay 2d. to travel to the next station, Oxford Circus, on the Bakerloo Line. Because there were no through bookings he had to pay 2d. more to travel from Oxford Circus to Bond Street, the next stop on the Central London Line. Now the fare from Piccadilly to Bond Street is one penny.

Such absurdities as lack of through bookings influenced the chairman of the London Passenger Transport Board (Lord Ashfield), who was then Mr. A. H. Stanley, to foreshadow the co-ordinated system of today when he arranged the London Passenger Traffic Conference. This conference was set up in 1907 to enable certain railway companies, tramway companies, and bus owners to confer concerning fares, routes, and subjects of common interest.

Since then the movement toward orderly passenger transport has marched forward steadily, shaped by internal exigencies and external pressure and directed with tact, patience, and insight by a few men who did not drop their eyes from an ever-enlarging vision of what London Transport ought to be and might be.

Although less than three years have passed since the London Passenger Transport Board was established, people are beginning to forget already the chaos that prevailed only a few years before it took charge. The Underground Railways and the Buses had joined forces, but competition was uncontrolled on the roads. One pirate bus would head off a company bus while another pirate bus raced to a stop and picked up passengers.

These cut-throat tactics had exciting and amusing moments, but so many buses poured into the streets that traffic became almost unmanageable and frequently unsafe. Long before this almost desperate last stage the fact had been accepted that the motive of private profit alone would not guarantee proper public transport. New facilities in advance of demand could be paid for only out of profits from already established routes. If these profits were squandered in competition, the efficiency of the system as a whole must degenerate and the extension of facilities be curbed, if not made impossible.

Ultimately the remedy determined upon was the transfer to a Board of five railway companies, fourteen municipally owned tramway undertakings, three privately owned tramway undertakings, 66 bus and coach companies and the whole or part of some 69 other omnibus and coach companies, as well as miscellaneous companies owning garages, works, lands, and so forth.

The Board is charged with the general duty of securing the

Illustrations Courtesy Transit Journal

Bus traffic during rush hours.

Short haul bus.

provision of an adequate and properly co-ordinated system of passenger transport in the London passenger transport area. For that purpose, while avoiding the provision of unnecessary and wasteful competitive services, it must take such steps as may be considered necessary to extend and improve the facilities for passenger transport. Further, the Board must conduct their undertaking in such a way that their revenues shall be sufficient to defray all charges.

Included in these charges is the necessity of paying interest on stock valued at £111,000,000. The total authorised capital of the undertaking amounts to £125,000,000.

The area which the Board serves is 1,986 square miles, of which 1,551 square miles are its exclusive territory. In the 1,551 square miles the Board possesses a monopoly of practically all public passenger transport excepting that provided by the suburban railways of the four Main Line Railway Companies.

The population for which the Board is responsible numbers 9,500,000. This is considered to be the largest metropolitan aggregation of population in the world. If certain portions of New Jersey be added to New York, London may have to take second place.

Geographically London Transport is concerned with little more than a fiftieth part of Great Britain, but this area carries more than one-fifth of the population of Britain, and within its borders lies, perhaps, half of the country's power and wealth.

In the year ended June 30, 1935, London Transport ran 534,000,000 service car miles over a combined route mileage of 2,770 miles. It bore its share in the carriage of 4,129,000,000 passengers whose journeys came under the London Passenger Pooling Scheme.

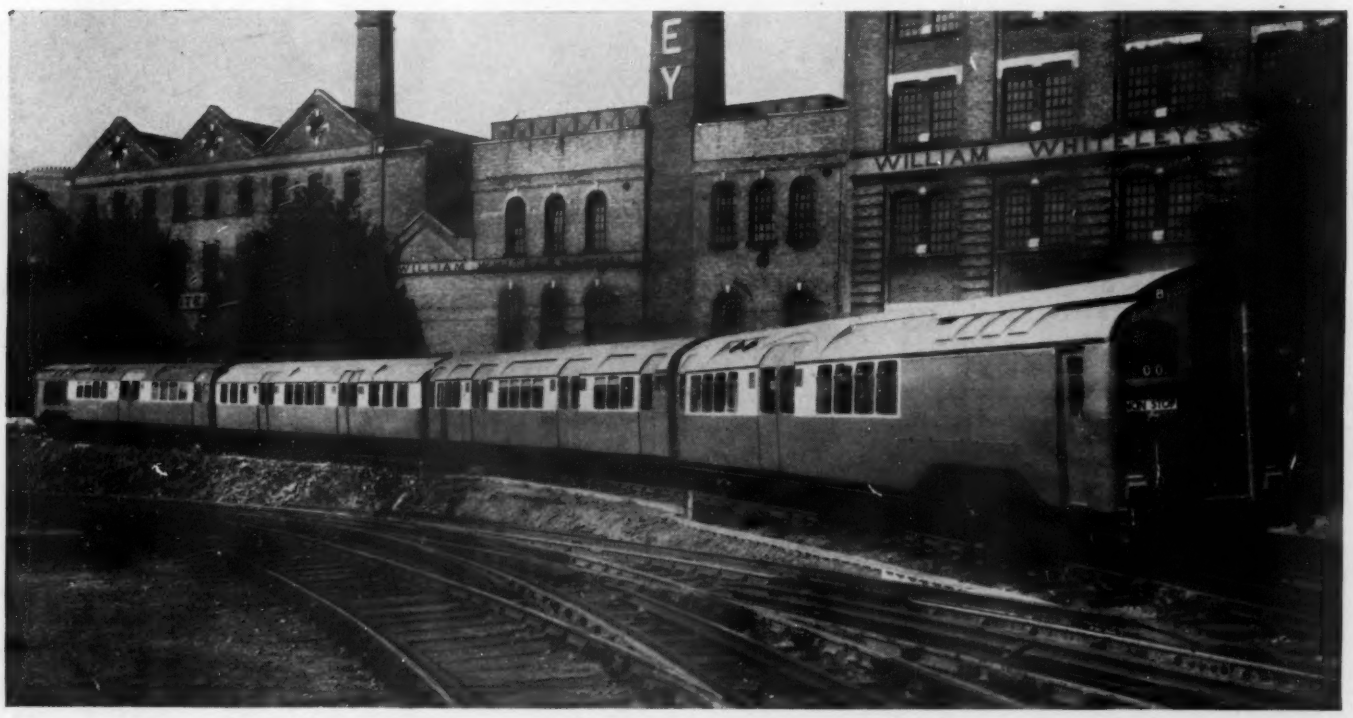
The extent of the Board's work is best measured by the 56 car miles a head of the population which it ran. If the 29 car miles run on the suburban services of the Main Line Companies be added, the number becomes 85, a standard not exceeded or even approached in any other city. Movement of traffic amounts to 377 journeys a head of the population. When the movement of the suburban lines of the Main Line Companies is added the total becomes 435 journeys a head of the population. Here again, the figure is the highest ever recorded.

The London Passenger Pooling Scheme is one of the least understood but one of the most important factors in the co-ordination of London Transport. It is the result of the work of accountants over a long period and very few people comprehend its intricacies.

In framing the scheme practically every journey made within 25 miles of Charing Cross in 1932 was examined. The proportions in which joint receipts are now divided were based upon the traffic habits of the population in that standard year.

The Pooling Scheme has done much more than establish a method of dividing net returns so that wasteful competition may be eliminated. It has also made it possible for the four

Train of the London "Underground."



Main Line Companies and the Transport Board to combine in a large scale programme of development and expansion. This programme, part of which has already been authorised by Parliament, will be implemented over five years. The cost will be £40,000,000 of which the Board's share will be £32,000,000.

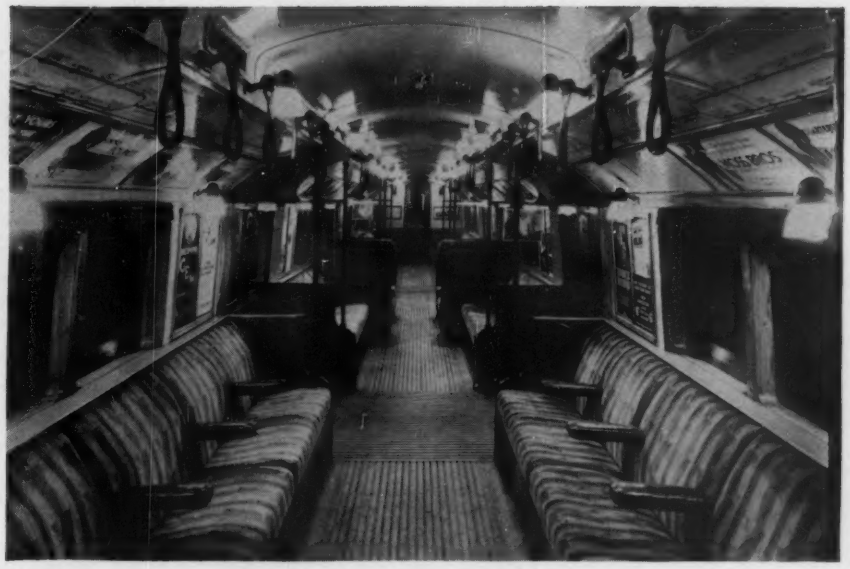
The five year programme is striking proof of the wisdom of establishing the Board. It is extremely doubtful whether the urgently needed work could have been undertaken under former conditions; certainly not for many years. Money could not have been obtained at a rate of interest sufficiently low to give reasonable prospect of financial success. Since it had to deal with five partners working in friendly co-operation a co-ordinated system, Parliament agreed to guarantee a loan of £40,000,000. The result is that the money has been procured at a little more than 2½ per cent and part of the programme is already under way.

The chief items of the five year plan are:

building 12 miles of new tube railway;
electrifying 70 miles of existing railway;
widening 20 miles of railway;
constructing more than 1,000 new railway cars;
installing escalators at 12 stations;
converting 139 miles of tramway to trolleybus;
inaugurating 9 miles of new trolleybus route.

When the new works have been completed and opened for traffic they will require 120,000,000 additional travellers a year for their support, so that despite the low rate of interest great care will have to be exercised if the additional expenditure is to carry its weight.

One of the reassuring considerations in estimating the future is the astonishing way in which traffic facilities in the London area beget traffic. Take, for instance, the Holborn Station in central London. At Holborn there used to be an exchange traffic between two Underground lines of 1,460,000 passengers a year. New interchanges were provided and the number of exchanges leapt to 9,800,000, an increase of 620 per cent in two years. There used to be no exchange at the Monument Station, which is in the City of London. In two years the number of exchanges jumped from nought to 5,900,000 a year.



Interior of London subway train.

Much of the new work will have the object of reducing congestion on the Underground Railways, but easier traffic means greater traffic; and at such a pace that the Board cannot hope to overtake the demands of peak periods.

It is hoped that within a few years it will be possible to run 8-car trains at the rate of 40 trains an hour on all the tracks of

Rapid transit station.

the Board. There will be such ready interchanges between lines as will further importantly the ideal of making the Underground railways a unified system instead of a collection of separate lines. But congestion will still prevail at times of peak loading.

The Underground railways carry 1,500,000 passengers a day. The peak periods last less than half an hour in the morning and less than half an hour at night. Such is the pressure during those brief peaks that to respond to it the Board has to maintain railway facilities capable of carrying 4,500,000 passengers a day.

Apart from longer and more frequent Underground trains, London Transport has taken many measures to cope with peak loading. All motor buses have been given covered tops so that they may be used to capacity in wet weather. The sizes of buses have been increased so that they seat almost twice as many passengers as did the early motor buses. More buses are being run than ever before. Indeed, it is practically impossible to place any more buses on routes that touch or traverse central London.

What then may be done? The fundamental problem is that London was not planned for modern needs. It has grown in a haphazard fashion in striking contrast to the orderly chessboard arrangement of modern American cities. It is a network of wide and narrow streets and a stranger almost inevitably loses himself unless he sticks to the chief thoroughfares. A street which by all the laws of logic and civic planning ought to intersect another street leads the unwary driver or pedestrian far astray.

Traffic lights, pedestrian crossings, and such devices are merely make-shifts. There is a compelling call for a bold programme of re-planning.

Public thought has turned lately to the advisability of staggering office and business hours. The pressure upon the Times Square Station, New York City, was offset by such an arrangement some years ago. Other cities have done likewise. It is absurd that everybody in London should go to work approximately at the same time and that all shops and offices should close about the same time.

Varying office and business hours is a remedy to which London Transport can do little more than direct attention, but it is felt that if shopkeepers and business people appreciated the delays, inconvenience, and the loss of business arising from the prevailing congestion, they would consider it in their own interests to arrive at a more rational arrangement.

Many aspects of London Transport have been mentioned in this article; hundreds of other aspects must go unmentioned. Some people, when they feel themselves getting out of depth in the details of the organisation, ask to be given an impression of the undertaking as a whole.

Supposing one were an artist and were commissioned to paint a picture symbolic of London Transport. The work could be begun with a loose background suggesting in broad brush strokes the vari-coloured surface of the London Transport area, ranging from the dense tones of London to the thin tones of the countryside. This background would have to convey also, in terms of form and colour, the interplay of influences which has fashioned the England of today, its people, its government, and its institutions, political and social.

Over this background there would be drawn lines of different colours to represent the various agencies of London Transport. One of the conventions of contemporary art expression could be borrowed so that the spectator might see beneath the surface into the tubes which carry the Underground railways. Erratic red lines would suggest the Central Buses, which are regarded so affectionately by Londoner.s The red lines would become more sober in pattern as they extended beyond the central London area to such distant places as St. Albans, where, a few hundred yards from the Central Bus terminal, a passenger may walk on the site of the ancient Roman municipium of Veralamium, where recent important excavations have been made.

Then there would be lines to indicate the sturdy tramway routes, many of which are now being converted for the use of the silent, sleek trolleybus. Pale green lines might indicate the Country Buses. The Country Buses are exactly similar except in colour to the Central Buses. But whereas the Central Buses force a tentative way in low gear through the packed streets of town, the Country Buses run gaily in top gear through the poetic lanes of the English countryside.

Only one element is needed to complete the pattern. Long, sweeping, dark green lines would stand for the Green Line coaches, which speed by long stages from London to more distant country centres.

But any picture of London Transport that was drawn today might not be true tomorrow. London and England are being redesigned. Swift, cheap transport is encouraging people to seek a larger, healthier life more distant from the centres of business. Industrial and business activities are being decentralised. Yet its shops, its theatres, and its restaurants exercise such attraction that all passenger transport must give direct access to the West End, which grows increasingly crowded.

It is a commonplace to say that no transport service can be static; but it is peculiarly true of London Transport. The outside forces which demand improvement are no more cogent than the internal forces which strive toward perfection.

The Development of the CYANAMID INDUSTRY *To Its Present Status*

By WALTER S. LANDIS
Vice-President and Director of the American Cyanamid Company

IF processes have a genealogy, we might trace that of Cyanamid back to the discovery of the South African gold fields and the introduction of the cyanide process. While the alkali cyanides had been known for a long time, the demand was rather limited, principally in the electroplating industry and slightly in the organic laboratory; the process of production was complicated and the price high. The low gold content of the ore in the South African gold fields necessitated the development of a cheap treatment process, a condition easily met by the MacArthur Cyanide Process provided the price of cyanide could be brought down to a reasonable figure.

The earliest sponsor of the laboratory work that preceded this process was a group interested in cheaper methods of making cyanide. The first laboratory work was an attempt to improve an older process based upon the conversion of barium carbonate to barium carbide, which in turn absorbs nitrogen to form barium cyanide. The barium cyanide was treated with sodium carbonate to produce barium carbonate and sodium cyanide in solution, from which it could be extracted. This process is somewhat complicated to carry out in practice although a commercial attempt at exploitation was made in Scotland about 40 years ago. Profs. Frank and Caro working for a German cyanide group realized that the barium process offered little hope of a material reduction in the price of sodium or potassium cyanide because of the high cost of barium salts and the low yields obtainable. They proposed the substitution of calcium carbide which was then being produced in a number of plants in Europe, and evidently assumed that such substitution would perform as did the barium carbide; for most of the early patents now long expired, which afterwards became fundamental in the Cyanamid industry, did not mention the word "Cyanamid" but related to "Processes for the Production of Cyanides."

This work was carried through to a point where considerable quantities of Cyanamid, which is a trade name given for the commercial form of calcium cyanamide ($CaCN_2$), was produced. It lacked the gold extracting properties of cyanide and there was much additional work performed in attempting to find a use for this product. Various derivatives such as ammonia, dicyandiamid, the guanidine salts, and the like followed, and about 1900 it was learned that it possessed merits as a direct application fertilizer.

The process development at that stage had also run into certain difficulties. Carbide could be purchased on the open market. This carbide they learned early had to be finely ground and this introduced certain hazards and difficulties in finding suitable equipment, since exposure to the air produced acetylene and acetylene air mixtures are highly explosive.

The finely ground carbide was then charged into a horizontal, externally fired retort similar to those used in the coal gas industry. Professor Frank, one of the inventors of the process, had long been recognized as an expert technologist in the gas industry in his native country, Germany.

The coal gas retort was not well adapted to this process since the capacity was small, necessitating a large investment, and the labor required for charging and discharging was excessive. The production of pure nitrogen on a large scale offered a problem, the only method known at the time passing the air through or over copper which absorbed the oxygen. The copper oxide was then regenerated by the use of a reducing gas. It was necessary to thoroughly dry the nitrogen before passing it over the carbide.

The absorption of nitrogen by carbide is an exothermic process producing a large excess of heat when once started. The coal fired gas retort was cumbersome for carrying out processes of this type, and one might mark the first really promising stage in the development of the process when the introduction of electric heating of the Cyanamid retort first came into use. From that time on the development of the process was rapid. It spread over the greater part of the world, and today there are more than 35 plants with a productive capacity of about one million tons of fixed nitrogen per year in operation throughout the world.

As carried out today the process may be briefly described as follows: Limestone is burned in rotary or vertical kilns to a hard burned product as free as possible from volatiles. Since the calcium is the only active element limestones of high purity are chosen. This burned limestone is mixed with a crushed coke or charcoal, that is, a reducing agent high in fixed carbon and preferably low in ash, and passed through an electric furnace of the arc-resistance type. The calcium oxide is here reduced and absorbs carbon to produce calcium carbide, well known in the trade for the production of acetylene. The Cyanamid industry, in most of its territory, requires a high purity carbide, that is one of 85 per cent or above, although there are commercial situations in Europe where it is still the practice to produce lower grade products that match up with some of the former nitrogenous fertilizer materials carrying 16 per cent nitrogen. In this case a high purity carbide is not necessary.

Carbide is tapped from the furnace, chilled and cooled and is then crushed and ground to about the fineness of an ordinary Portland Cement.

There has been a steady development in the engineering features of carbide furnaces, and the early ones of a few hundred horse power have for the greater part been displaced by furnaces consuming up to 40,000 K. V. A. in a single unit. The furnaces today all use alternating current and most of them are three-phase, three-electrode type. Some idea of the size of these furnaces may be gained from the fact that currents as high as 100,000 amperes pass through a single electrode, these electrodes having a cross-section as high as 20 to 25 square feet. Some of the furnaces use pre-formed electrodes which are built up into a composite block; others use electrode mass charged into forms and which are automatically baked as fed into the furnaces. The larger furnaces tap practically continuously.

For the crushing and grinding of carbide, the apparatus must be sturdily built since the product is quite hard and tough. Further, it must be entirely enclosed to prevent access of air which decomposes the carbide through its moisture content. The entire crushing and conveying equipment must be supplied with an inert atmosphere to prevent explosion.

The ground carbide is then charged into a well insulated electric oven, of which there are two systems in general use. Most Cyanamid plants use the so-called fixed ovens, that is, a permanently mounted shell, usually cylindrical in shape, insulated with refractories, and into which some form of container is placed carrying the ground carbide. The oven itself is connected to a source of pure dry nitrogen, now obtained exclusively by the liquefaction of air, but formerly obtained by the so-called copper method briefly described above. A thin carbon rod is inserted in a tubular channel placed axially in the carbide charge and so arranged that it can be electrically heated by the passage of a heavy low voltage current. After the furnace is charged with carbide and the pencil inserted and the whole closed up, nitrogen is turned on to flush any air out of the oven, and then current is applied to the resistor. This heats the surrounding carbide to incandescence, and the red hot carbide absorbs nitrogen, the reaction being a simple one: $CaC_2 + N = CaCN_2 + C$. It is only necessary to supply heat long enough to start the oven for the exothermic development will carry the reaction to completion. These furnaces vary in size depending upon the age of the installation, the early ones carrying 1,000 pounds of carbide and the present day modifications holding from three to five tons, although units as large as 15 tons have been constructed. The absorption is slow, requiring a week or more for completion in the larger ovens, but no attendance whatever is required during the absorption period.

A system has also been developed with several modifications involving a mechanical type of Cyanamid oven in which the carbide is continuously fed into the oven and the Cyanamid produced continuously removed. Then there is a cross-breed of oven in use in Europe in which the carbide is charged into containers and the containers progressively moved through a tunnel-like structure with nitrogen fed in one end. Heating elements installed in the roof radiate sufficient heat to start the operation. Air locks at the ends make this more or less of a continuous operation.

The finished Cyanamid sinters during its production into a solid block in the static type of furnace, which block is removed at the completion of the absorption, passed through crushers and fine grinding equipment. It carries a small percentage of residual carbide, and in preparing for market it is customary to destroy this carbide by the addition of a small amount of water in a continuous mixer. In most countries the dusty character of the product is objectionable, and a small amount of oil is added to hold down the dust. More recently processes of granulation have made headway; these processes compacting the fine powder with or without the use of a binder into grains which because of their size, are not dusty.

Formerly the nitrogen required for the process was produced by passing air over a copper mass made of copper shavings, copper oxide, and an inert porous binding material. The oxygen was fixed by the copper, the nitrogen passed through to drying apparatus and then to the Cyanamid plant. This process, looked upon ordinarily as a convenient laboratory tool, was developed by the Cyanamid industry to a highly complex unit, the retorts carrying the copper being as large as four feet in diameter and six to eight feet high and carrying tons of copper. Hundreds of these units made up the nitrogen plant. They were operated in cycles passing air through for several hours after which reducing gas regenerated the copper in a short, rapid reverse cycle. They were displaced by the development of the modern process of liquefying air and rectifying the liquid to produce pure nitrogen. The liquid air process which now has single units large enough to produce 100,000 cubic feet of nitrogen each per hour, operate very much more cheaply than the copper process and produce nitrogen of superior purity. In most plants the oxygen is turned to waste since the quantity involved is greater than could be used at the site of the Cyanamid plant. The purity of oxygen in the modern unit is better than 90 per cent as it is discharged into the air.

The development of the Cyanamid industry since the inception of the first plant in 1905 has been largely engineering in character. The individual units have multiplied many times in size and with them a multiplicity of handling and conveying equipment. Forty years ago the largest lime kiln in a Cyanamid plant had a capacity of about 10 tons of lime per day. The present modern rotary and the gas-fired vertical kilns have a capacity of well over 100 tons of burned lime in each 24 hours. Naturally these larger units are all mechanically fed.

The original carbide furnace a few years ago, some of which are still in operation in Europe, consumed 500 horse power. The modern furnaces in this country are rated at 30,000 horse power, and one or two even larger units up to 40,000 horse power have been installed abroad. The small furnaces were charged by hand. The modern large furnaces require mechanical feeding and have mechanical tapping arrangements with mechanical cooling system for handling the great volume of carbide produced by the single unit.

The Cyanamid ovens themselves which originally held some 500 to 1,000 pounds of carbide per unit, now hold three to five tons and in specific cases are larger. With the mechanical handling equipment there is even less labor required per modern large unit than was used in the early small units.

Crushing equipment has kept pace with the size of the units, and in this particular case we have had the benefit of the extensive development of the mining industry.

Better knowledge of the effect of impurities in our raw materials has enabled a much more efficient operation from the standpoint of materials consumed. The thermal efficiency of the large electrical units has correspondingly reduced power consumption. Back in 1905 it was estimated that nitrogen might be fixed by this process with the expenditure of about three horse power years per ton of nitrogen. This was looked upon as a remarkable advantage over the single competitive fixation process of those days, that of Birkland-Eyde which consumed about 12 horse power years per ton of nitrogen. Today we look upon a plant as inefficient that uses as much as 1½ horse power years per ton of nitrogen. In consequence of this saving in power it has been possible to build Cyanamid plants as adjuncts of steam driven power plants of which there are several examples in Europe. Power is still the most important item of cost, and the process is, therefore, limited to cheap water powers and cheap fuels.

The process itself developed slowly until the outbreak of the war in 1914 there being less than a dozen plants in existence at that time and many of them quite small. Geographically they were found in Norway, Sweden, Germany, France, Italy, Switzerland, Dalmatia, and Canada. A Japanese plant was then just going into operation. During the war the demand for fixed nitrogen in Germany and Austro-Hungary, both countries lacking the potential possibility of large hydroelectric developments, forced attention to the Cyanamid process and the German and Austro-Hungarian productive capacity was enormously increased by the building of several large new units. By the end of 1916 Germany, for example, had increased her capacity from about 30,000 tons of nitrogen per year at the beginning of 1914 to about 600,000 tons by the end of 1916. Before the war had ended additional capacity including five plants in France, one plant in the United States and enlargements of Italian plants had very markedly increased nitrogen fixation throughout the world by this process. The one plant built in the United States at Muscle Shoals never has been put into peace time operation, and since its equipment represents the development of 1916–17, it is today quite obsolete.

(*Continued on page 101*)

Unusual Versatility Allows

BAKELITE

To Surpass Natural Resin

By MARC CUTLER, '39
Massachusetts Institute of Technology

IT was approximately one hundred years ago that Friedrich Wöhler, in Germany, and Marcellin Berthelot, in France, made the first organic synthesis. Their work laid the foundation for modern organic research by which the chemist seeks to duplicate natural materials. Sometimes he goes even beyond this imitation of nature and makes combinations of matter which have never before existed.

Not many decades ago the world decided that it wanted a resin that would not melt; one that would accomplish a thousand things that natural resins, no matter how they were treated, would not do. In short, the world clamored for a super-resin, a resin that had properties that natural resins, obtained from trees, did not have. It was no secret that carbolic acid and formaldehyde, properly combined, would produce some kind of a resinous substance. In 1891, Kleeburg sought to find the solution of synthetic resins, but when he could not obtain crystals he became discouraged. Kleeburg was within reaching distance of what is now known as Bakelite, but he did not realize the fact. He did obtain a hardened blob that resembled nothing he had yet produced. This material resisted most chemical reagents, and boiling with acids did not affect it, but what Kleeburg was looking for were crystals, so he gave up the job.

In 1906, Leo Hendrick Baekeland began the search for the

4200 gallon tank, nine feet in diameter by nine feet deep, molded in one piece. Wood staves and steel hoops are used to add support while the tank is in service.

Illustrations Courtesy Modern Plastics

solution to the phenol-formaldehyde riddle. After using all possible solvents and methods of melting the synthetic resin, he saw Kleeburg's error. Each had obtained a substance that was insoluble, infusible, and resistant to solvents, acids, and oils, that could be used as a gum, but was far more valuab.e as an indestructible solid. Kleeburg did not realize these facts, but Baekeland did. He realized that his task was to bring it to workable solidity and still preserve all the valuable properties of its early viscous state. Where his predecessors sought lasting solubility and fusibility in acids, Baekeland found final hardening in bases. The reaction of the phenol and formaldehyde, which occurs in the presence of heat, tends to produce foam, which tendency, he discovered, was reduced by the addition of small amounts of sodium hydroxide which also helped to harden the resin. Baekeland found that his final product possessed most of the physical characteristics of natural resins, and, in addition, had the unique property of becoming infusible and insoluble after heat treatment.

Synthetic resins may be divided into two physical and two chemical classes. The physical classifications consist of: (1) permanently soluble resins; (2) initially soluble resins that become hardened under the action of heat. The second type are the phenol-formaldehyde resins, such as Bakelite.

Chemically, synthetic resins are divided into *condensation* and *polymerization* classes. The term *polymerization-resin* is used to designate a resin which is formed directly by the polymerization of a chemical compound, without passing through a preliminary stage of condensation. Polymerization is the chemical process in which relatively simple molecules of a compound become complex by combination among themselves. Such a reaction is usually initiated by light, heat, strong acids, or strong alkalis. Bakelite and other formaldehyde-phenolic resins are *condensation-resins*, which are formed by the direct union of the molecules, and condense with the elimination of water.

The production of Bakelite is comparatively simple for a substance that took over half a century to perfect and that has innumerable uses. The initial materials are phenol and formaldehyde. Phenol is obtained as a by-product of the coke oven; formaldehyde, by the partial oxidation of methyl alcohol, which is brought about by passing methyl alcohol vapors with air over a catalyst of finely divided metal.

Weighed quantities of pure phenol and formaldehyde solution (formalin), with a small amount of caustic soda, are placed in a steam jacketed kettle that is provided with gear for stirring. The steam is turned on, and within a few hours the reaction is complete. After becoming cloudy, the mixture finally separates into two layers, an oily aqueous layer on top and a layer of the molten resinoid below. The reaction takes place under pressure in order to aid the sodium hydroxide in preventing the mixture from foaming. The alkali also tends to produce a hardening effect upon the final product.

When the mixture finally settles into the two layers mentioned above, the molten resin is drawn off and freed from water. At this stage, Baekeland called his product "Bakelite A." Bakelite A will respond to solvents and will flux upon being moderately heated, but if subjected to a high temperature, it becomes, on cooling, a hard, brittle, transparent, amber-like solid. This solid is practically indestructible; it is insoluble in all known solvents, and is impervious to most chemicals; it does not melt, but at 300 degrees Centigrade it chars and then burns with great difficulty; its surface resistance to electric current is four times as great as that of plate glass at 90 per cent humidity; it is more elastic than ivory; it cannot corrode, as do metals.

The imperishable quality of this phenol-formaldehyde resin lends it to innumerable uses. In the condition of Bakelite A, the plastic is workable, that is, it may be molded, mixed with fillers, rolled, or made into liquid products.

From its workable stage, the resinoid is converted into a number of forms in which its properties are modified, or amplified, in order to suit it for special requirements. These forms comprise four general classifications:

1. Molding materials;
2. Transparent materials;
3. Liquid products—varnish, lacquer, enamel, cement;
4. Laminated sheets, tubes, and rods.

Wood-flour or sawdust, sifted and dried, is mixed with the unpolymerized resin, and the two are ground together for several hours. The resulting powder is then run between hot rolls, causing the wood flour to be thoroughly impregnated with the molten resinoid. Sheets of material resulting from this operation are ground to powder which is then sifted and thoroughly mixed to insure uniformity. This powder constitutes the *molding material* ready for market. When this mixture is placed in a mold and heat and pressure are applied, the granular Bakelite first melts and the steadily increasing pressure forces the plastic into the crevices of the mold. Increasing the pressure to about a ton to the square inch and the temperature to about 350 degrees Fahrenheit causes the resinoid ,after only a few minutes, to be transformed into its permanent, strong, infusable, insoluble state. The molded object is removed with little or no cooling. Dozens of objects may be molded at the same time in multiple cavity or gang molds.

An amber-like *transparent material* may be produced by pouring the molten Bakelite A into molds and performing the same process mentioned above. In this product no filler, of course, is used.

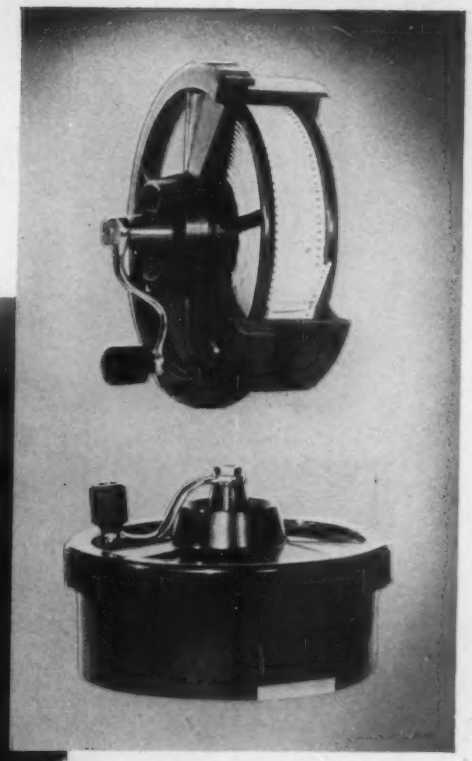
If the soluble Bakelite A is dissolved in a suitable solvent, as alcohol, a *liquid product* is produced, which is used to impregnate electric coils and windings. When baked at temperatures ranging from 170 to 350 degrees Fahrenheit for from one-half hour to several hours, an excellent insulator is produced. Bakelite liquid products are used for numerous purposes which will be discussed later.

In the manufacture of the *laminated material*, the same unpolymerized resin is employed. Again, Bakelite A is utilized by dissolving it in alcohol to form a solution. Into this solution are dipped sheets of paper or cloth, which, after being freed from the solvent, are piled on top of one another and subjected to heat and pressure. The resinoid melts, and, as in the case of the molding materials, binds the filler, thus forming a tough plate which possesses all the characteristics of the phenol-formaldehyde resin. It is hard to eliminate the idea that the sheets, tubes, or rods thus formed are not merely paper. The paper is there, but it is not paper. In its stead has come into being a strange solid that looks like wood or wax, but is neither one. Try to break a little rod, the thickness of your smallest finger. When you have to put it over your knee to crack it, you will realize that the paper state has ended. From this remarkable laminated material countless articles are carved by means of lathes or other machines, and by hand.

The production of this proficuous plastic is not without hazard; the dangers in the process of making the substance are as silent as the process itself. The basis of the resin, phenol and formaldehyde, are each highly irritating to the human skin. Phenol compounds frequently cause a common condition known as *phenol gangrene*, while formaldehyde, an irritant substance, may produce severe redness and inflammations of the skin. Knowing these facts, the manufacturers of Bakelite use enclosed apparatus during the production. Through carelessness, however, it is quite possible for the substance concerned to come in contact with the skin of workmen and to produce severe irritations.

In the second phase of Bakelite manufacture, the resin made in the enclosed process is manipulated as a dry powder (Bakelite A) or as a liquid resembling varnish. In this work industrial alcohol or benzene may be employed. Deaths from

Fairchild Aerial Camera in which phenolics play an important part. Using Bakelite for the two film guide rollers of each magazine has been found to reduce trouble which formerly occurred. At the right is the Davidge Film Laboratory developing tank—all molded.



benzene poisoning have been recorded. Numerous cases have occurred of the irritation of the skin by benzene, which acts as an irritant by dissolving the fat from the skin and thus making it hard and brittle.

When Bakelite powders are made into hard objects the phenol-formaldehyde resin powder is diluted with a filler used to the extent of ten percent. This filler is usually a drug known as hexamethylenetetramine, used in medicine in infections of the bladder. It is a skin irritant and in the presence of heat and perspiration may bring about irritation of the skin of workers handling Bakelite.

After Bakelite leaves the manufacturing plant and the molder, however, it no longer has these irritating properties, which fact is testified to by the extensive use of the plastic. The services to which Bakelite are applied, or may be applied in the near future, are so numerous that it is difficult to classify them under general heads, or even under the four commercial forms of the resin (molding, transparent, liquid, and laminated materials).

The resin is extremely valuable to the electrical world in the form of an insulator or non-conductor. Coils are dipped in the liquid product to effect an insulation; thin laminated sheets are used as dielectrics in certain types of condensers; the molded material is utilized in any shape or size socket, switch or dial; in general, Bakelite is replacing (or has already done so) numerous uses of rubber as an insulator and as a casing for electrical equipment (such as the telephone).

In automobiles, boats and airplanes, this synthetic plastic has a wide range of functions. Laminated sheets of the resin are machined into the silent gears of automobiles; it is manipulated into distributor heads, self-start- ers, instrument casings, ornaments, and a dozen other items on motor cars. "When a few German battleships fell into English hands they were found to have Bakelite all over them. The most significant demonstration . . was the switchboard of the ship's electrical control equipment, a thick thing, made of Bakelite and asbestos. It had had some hammering in the course of the discussion, but it didn't shatter, and it was functioning when the fuss was over." In airplanes, this synthetic resin is used as abundantly as in automobiles. The propellor which carried the Maitland-Hegenberger plane over the Pacific to Hawaii, was made of a form of Bakelite material.

The field of Bakelite extends into that of paints and varnishes. It provides a protective covering for varnished and enameled objects. It is used in the preservation of fossils, because of its superiority to varnish in providing a more elastic and a practically indestructible coating.

The applications of this versatile plastic do not stop with industry, but extend into the home. Its domestic and household uses range from table tops to decoration of textiles. As cups, saucers, bowls, plates, lamps, electrical equipment,

(*Continued on page 100*)

Opportunities Appear For

THE YOUNG CHEMIST

In Government Service

By LOUIS MARSHALL
Senior Chemist, United States Civil Service

EVERY student who intends to make chemistry his life work should know that one of the most important fields of employment for the chemist, whatever his specialty, is the civil service. The United States government employs about one thousand men and women who specialize in chemistry, and there is no subdivision of that great science which escapes investigation in one or more of the government laboratories. Moreover, the achievements of these scientific men and women have enhanced the standard of living of our nation; providing us with wholesome unadulterated foods; raising the standard of the public health; improving the quality of the clothes we wear and the innumerable articles we buy; safeguarding the water we drink; and in certain industrial sections of our country, cleansing the very air we breathe. Our nation's investment in science is drawing its full dividend in the betterment of the welfare of its inhabitants.

The Civil Service Commission of the United States has sought to interest college graduates in government service. Examinations for the position of Junior Chemist are held each year for students who have majored in chemistry. Below are included some interesting figures concerning recent examinations for Junior Chemist.

Year ending June 30	*No. Male*	*Exam. Female*	*No. Male*	*Passed Female*	*No. Male*	*App'l Female*
1928	*261*	*32*	*106*	*8*	*54*	*3*
1929	*357*	*58*	*201*	*24*	*70*	*3*
1930	*425*	*69*	*151*	*15*	*69*	*3*
1931	*1030*	*143*	*462*	*63*	*44*	*1*
1932	*No general examination.*					

Since 1931, however, the eligible lists of chemists have been so ample, and appointments so few, that the government has not deemed it desirable to hold further junior chemist examinations.

The writer of this article received his degree in 1930, took the examination in February of that year and received his appointment in July. He confesses a deep feeling of sympathy for those students who have since been graduated and through circumstances entirely beyond their control, have been denied the opportunity to serve their government as chemists. He sees, however, a ray of light which he feels will dispel this gloomy condition. For it is rumored that the Civil Service Commission will soon resume its policy of conducting each year an examination for Junior Chemist.

Du Pont Magazine

The examination is a written one and consists of two parts. The first part, in general chemistry, is required of all candidates. The second part, the student may elect to take the examination in one or more of the following subjects: Organic, inorganic, physical, and analytical chemistry. Separate lists of eligibles are made up from these examinations. The observer of civil service matters cannot help being impressed by the utter impartiality of the whole proceeding. The Candidate is warned in his application form to avoid reference to religion, politics, or fraternal orders. The examiner who rates the candidate's paper, knows him only by number.

The writer received his appointment from the eligible list in analytical chemistry. The work consists in the analysis of a wide variety of materials to determine their compliance with the specification requirements. For instance, the type of spaghetti that is purchased by the Navy Department must have an ash content of less than 0.65%, moisture less than 12%, and protein at least 11%; baking powder has definite requirements for aluminium, phosphorus, and available carbon dioxide; vanilla flavor purchased by the Navy contains at least 0.1 gram of coumarin, 0.6g. vanillin, and 35c.c. of glycerine per 100c.c. of the product; vegetable shortening should have an iodine number of less than 75; canned sausage may contain not more than four times as much moisture as protein; crude fiber in cocoa must not be over 7% calculated on a fat and moisture free basis; gold lace should contain at least 2% gold and 90% silver; silk neckerchiefs must not be too heavily weighted; cotton fabrics must be free from artificial sizing such as starch; wool-cotton mixtures must contain a minimum percentage of wool; tableware should contain at least 18% nickel; white floating soap should contain an acid number of at least 212; the titer of the mixed fatty acids prepared from neutral chip soap should be not lower than 39 degrees Centigrade, and so on.

The work is thus seen to be of a rather strict analytical nature although there is plenty of room for ingenuity and research ability as applied to the improvement of methods of analysis. The preparation of accurately standardized solutions of acid, alkali, silver nitrate, ammonium thiocyanate, sodium thiosulphate, etc. is of course a necessary part of this work.

The first appointment which the Junior Chemist receives is likely to play an important role in his career. Transfers are rather difficult to obtain, and many a chemist has reached the retirement age in the laboratory where, as a young man, he first began his work. Thus, if the first appointment is to a research laboratory, located in a city where opportunities for graduate study are available, the young chemist can well develop into a recognized specialist in his particular field.

Most of the research laboratories, though by no means all of them, are located in Washington, D. C. This city is very favorably situated, from an educational standpoint. The local universities conduct special late afternoon and evening sessions for

government workers. It is entirely possible for a young man to win his Ph.D. degree by attending these classes after working hours. Some government departments, like the Department of Agriculture, give courses to their younger scientific workers which are credited by the local universities. This department employs more chemists than any other in our government. Its vast organization is divided into bureaus under which widely diversified and important researches are conducted. The Bureau of Animal Industry tackles problems concerning the feeding of animals and the nutritive value of the different animal foods eaten by man. The Bureau of Chemistry and Soils deals with the chemistry of farm products like sugars, starches, sirups, citrus fruits, etc. One of its divisions is engaged in the study of the causes and means of prevention of dust explosions. The productivity of soils is studied. The influence of fertilizer treatment on crop yield receives attention. The fixed nitrogen researches of this bureau require all the tools of modern physical chemistry, physics, mathematics, and engineering.

The Bureau of Dairy Industry conducts researches of a fundamental nature concerning the nutrition of the dairy cows and the manufacture of dairy products. The work involves chemistry and bacteriology. The organic chemist, for instance, studies milk powder, evaporated milk, the oxidation of fats in the deterioration of butter, and heat stability of ordinary milk.

The Food and Drug Administration, employing more than 150 chemists, is charged with the enforcement of those comprehensive acts of Congress designed to safeguard the quality of our food and drink. Many new methods of analysis have been developed by this bureau. These are written into the specifications of the particular foods which they concern. The methods they employ to standardize foodstuffs are chemical, pharmaceutical, and microscopical. Their organization has succeeded in giving the American public a food supply that is unsurpassed anywhere in the world. Ketchup as well as evaporated milk, jam as well as cocoa, all engage their attention. This bureau is also responsible for insuring that medicines and drugs sold to the public are of standard quality, unadulterated, and not misbranded. Their inspectors who investigate the processes of manufacture in the food and drug trades are frequently taken from the civil service eligible list of chemists.

The Forest Service, another important bureau of the department, has its research laboratory located in Madison, Wis. The work there involves theoretical and practical scientific studies in the chemistry of pulp and paper manufacture, glue, wood preservatives, and paint application. The work is carried out in co-operation with the University of Wisconsin, and the chemists there are afforded an excellent opportunity for graduate work. They may receive university credit for research work done in the government laboratory.

The Bureau of Plant Industry, as its name indicates, is devoted to plant research and related problems. Men who received their early training in organic and physiological chemistry, have entered the field of plant physiology and have found their chemical training to be of fundamental importance to them in their work. The work of this bureau on plant diseases and methods of eradication and control has found vast practical application. A valuable adjunct to the work of this bureau is the experimental farm which it maintains at Arlington, Virginia near the District of Columbia.

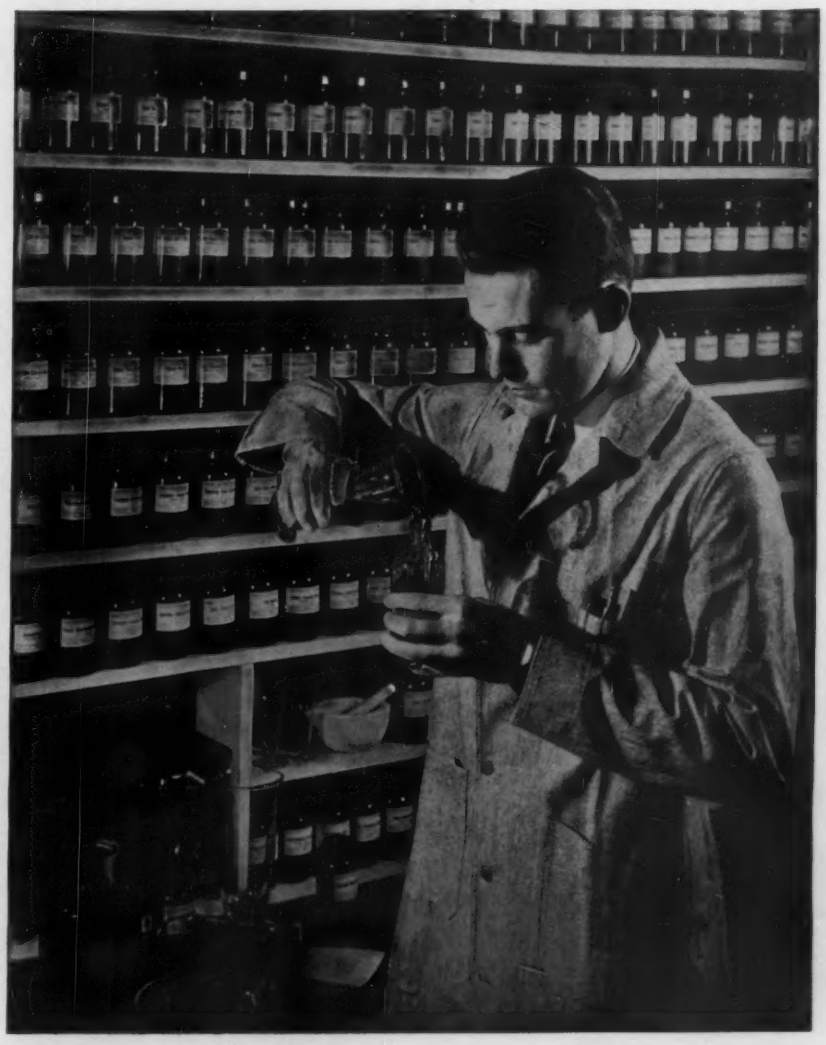
The Bureau of Home Economics is a stronghold of the woman chemist. The important field of vitamin research as a part of general nutrition receives the attention it merits in this bureau. The chemists there also study the composition of textile fabrics and the effects of reagents used in the household on these materials.

Another department of the government which employs chemists is the Department of Commerce whose Bureau of Standards is known the world over for the precision and elegance of its work. About one hundred chemists serve in this great institution. Other departments employing chemists are the Department of the Interior with its Geological Survey division, The Navy Department with its Bureau of Supplies and Accounts, The Treasury Department which controls the Public Health Service, and the War Department.

According to the official government specifications for the position of Junior Chemist, he is called upon, "To assist chemists of higher grade by performing routine steps in chemical research requiring fundamental technical training but not involving the necessity for mature judgment, the responsibilities for interpretation of data, or the authority to make recommendations on the basis thereof." He may be called upon to make a great variety of chemical analyses most of which are in accordance with standard laboratory methods.

The entrance salary for the Junior Chemist is $2,000 per year. He can win promotion through the grades to assistant

(*Continued on page 104*)



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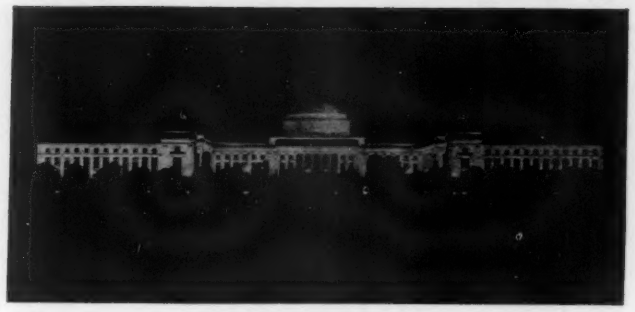


EDITORIALS

CURRENT RESEARCH

RECENTLY those taking second year Physics under Professor Wulff were given an opportunity to visit several of the research laboratories in the Institute. On two occasions the class was divided into several groups of about ten each; these groups then were to visit the laboratories according to a predetermined schedule. Students making the tours have an opportunity to see the spectroscopy laboratory, X-ray laboratory, electronics research, the color analyzer in operation, atomic and nuclear research laboratory—all of the Department of Physics—the stress analysis laboratory of the Department of Mechanical Engineering, the illumination laboratory of the Department of Electrical Engineering, and the crystallographic laboratory of the Department of Mining and Metallurgy. When the first tour of inspection was completed, everyone gathered in the Moore Room for a tea where everyone closely associated with the research laboratories which had been visited was present. This gave everyone an opportunity to ask questions about and discuss the things which they had just seen.

It is not often that a professor takes such an active interest in showing the student that the elemental subjects which he is taking have very direct application in the research front of today—that the work which he is doing leads to something of vital importance yet to be discovered—that his courses lead to something that is full of the romance of speculation.

Too often the student must hunt up news of current progress in research in some obscure scientific or technical publication. He, moreover, under the pressure of his studies has little time to look up such publications. A well-balanced picture of his field is kept from him because of the limitations imposed by a present system.

The professor, in contrast to the student, has intimate contact with research men and their accomplishments. He takes part in a particular field of research and knows the significance of developments in other fields. He is in a position to give the student a better picture of his field.

It is seldom that a professor voluntarily assumes the responsibility of showing his students a live field rather than one which exists purely in textbooks, especially when these students are in their first two undergraduate years. It is, however, the way in which the present courses may become more complete and the graduate engineer given a true picture of his field. In the future let us hope for more of such active leadership.

T. E. N. AWARDED YALE CUP

Below is a copy of the letter sent to the former General Manager of the *Tech Engineering News*.

Dear Mr. Shainin:—

It is a pleasure for me to inform you that the *Tech Engineering News* was awarded first prize in the 1935-36 competition conducted by our magazine to determine the most outstanding undergraduate scientific publication in the United States. You do, therefore, according to the terms of the contest, gain permanent possession of the Yale Cup which is now in your hands.

Complete details of the contest will appear in our Summer issue, but I will say at this time that the New York University Quadrangle and the Co-operative Engineer tied for second place and that the Armour Engineer received Honorable mention.

Allow me to offer my congratulations and best wishes to you and your Board.

Very truly yours,

(Signed) Richard L. Steiner
Chairman, 1935-36

ANNOUNCEMENT

THE Managing Board takes pleasure in announcing the following promotions: To the position of Assistant Editor: R. Dixon Speas, '39, Harold Chestnut, '39, and Amos J, Shaler, '39; to the position of Assistant Managing Editor: Irving Peskoe, '39, Monarch L. Cutler, '39, and Joseph J. Donovan, '39; to the position of Assistant Advertising Manager, Richard S. Leghorn, Jr., '39, and Robert S. Laird, '39; to the position of Assistant Circulation Manager, Augustus A. DeVoe, '39 and Thomas E. Langs, '39; to the position of Assistant Treasurer, Paul B. Farwell, '39; to the position of Assistant Publicity Manager, George D. Cremer, '39 and John C. H. Lee, Jr., '39; and to the staff, Maynard K. Drury. It is hoped that these men will continue their good work and carry on to positions on the junior board.

CHALLENGE OF FOG

FOG, recognized as the one remaining major obstacle to the development of air transportation, is deservedly a subject of constant experimentation. In order to free air travel of the charge of unreliability, it is necessary to overcome the detrimental effects of fog, and only through careful research and investigation can this be attained.

It has been found that there is no appreciable difference in the fog penetrating ability of the various members of the visible spectrum. It is known, however, that the infra-red ray are decidedly more penetrating through smoke or haze than other members of the visible spectrum. This is evidenced in the apparent redness of the sun upon nearing the horizon or during a forest fire, which facts show that the infra-red rays are very effective in penetrating haze and smoke. Modern day photography takes advantage of this fact in obtaining a clear picture through smoke or haze, and through careful research and experimentation some medium could and should be developed to present the pilot with the same picture instantaneously. Although not solving the straight fog problem, such a development would prove an enormous aid to pilots during conditions of smoke and haze.

The fact that there is a ray in existence, infra-red, which can penetrate haze and smoke gives rise to a hope that there is another ray which goes a step farther and penetrates fog. The discovery of this ray and a medium whereby it may be converted to a visible ray, would lead to a most valuable solution, for thereby a pilot could have complete knowledge of his location at all times without aid from any outside agency.

Therefore, since there is no fact which denies the existence of such a ray, it is the duty of science to exhaust every possible means of finding it and developing its many possibilities.

ZEPPELINS

AS we go to press the Zeppelin *Hindenburg* has arrived in Lakehurst and once again Dr. Hugo Eckener and his crew have shown the feasibility of a transatlantic Zeppelin service.

We, Americans, because of our bad luck with dirigibles, have a tendency to be prejudiced against these big "gas bags." We refuse to believe that anything could be better than our giant flying boats that span the Pacific at 150 miles an hour. The performance of the *Graf Zeppelin* and the *Hindenburg*, however, show that the Germans are able to build airships that, while they are not as fast as airplanes, are more spacious and comfortable, have a greater cruising range, and do not come down if their engines fail. The luxuries on the new *Hindenburg* are enough to put the flying boats to shame. With a bar, a grand piano, a smoking room, the *Hindenburg* is in many respects like an ocean liner.

A small group in the navy, headed by Commander Charles E. Rosendahl, are working steadily to get our government

(*Continued on page 103*)

ENGINEERING DIGEST

AIR COMPRESSOR

THE Unitair is a two-stage, completely air-cooled, V-type single acting stationary compressor, incorporating many advanced features.

Cylinders are cast separately to give greater heat radiation and increased surface for contact of cooling air from the ventilating fan. Encircling horizontal fins give great rigidity and strength for the cylinders and also increase heat radiation surface.

The V-design affords balance of reciprocating parts and thus eliminates vibration. It permits a short crankshaft for compactness—places the cylinders in easy reach—makes air cooling so effective that the compressor may be installed anywhere without dependence on water supply.

A single plate valve at the head of each

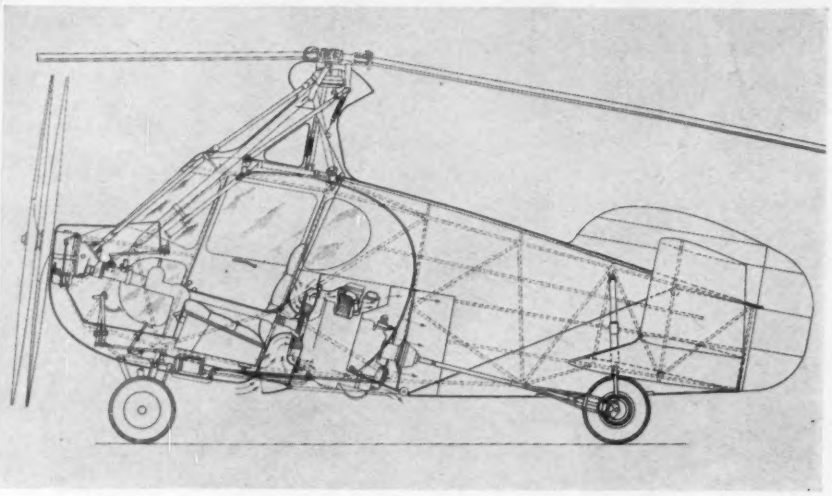
cylinder provides for both intake and discharge of air and is so arranged that valve travel is reduced to a few thousandths of an inch, giving 6 to 8 times longer valve life, with trouble free operation and reducing power consumption. Despite their sturdy quality these valves—known as Microlift Valves—are so light that both the intake and discharge valves can be suspended by a single hair. Their low lift reduces destructive pounding to a minimum.

Complete inspection of the compressor is possible by merely removing the cylinder head. This single operation brings into full view the head, the valves, the piston, and the cylinder walls —an advantage of great importance to successful, continuous operation.

Paired two-stage cylinders with intercooling between reduce power requirements; and trouble-free ball bearing main bearings facilitate operation and increase the life of the bearings.

These compressors are available in four sizes (two sizes in the two-cylinder type and two sizes in the four-cylinder type.) Capacities to 400 C.F.M. displacement. They can be furnished with built-in-motor of the induction type; or for direct connection, V-belt drive or flat-belt drive from gasoline, distillate or Diesel engine, or electric motor.

—Sullivan Machinery Co.



THE GIRO RETURNS

REPRESENTING a revolutionary departure in design from the autogiro of two years ago, a new roadable direct control autogiro is nearing completion in the Willow Grove, Pennsylvania, factory of the Autogiro Company of America. With newly developed take-off device, direct control, and roadability features, this type promises to be the prototype for the next giros to be put into commercial production. This wingless ship is indeed a far cry from the old fixed wing types, the production of which was suspended two years ago when it was seen that they were not commercially practical at that stage of development.

Details of the jump take-off mechanism are not yet available, but it consists of a hydraulic device which twists the rotor blades to a zero lift incidence. The rotors are then turned at a high rate by the motor and a suddenly restored positive pitch causes the potential energy stored in the rotor to lift the ship twenty to thirty feet vertically from a standing start. The three blades of the rotor may be folded back over the body in order to facilitate storage.

The engine is mounted inside the cabin behind the seat and is cooled by means of a fan. From the rear of the engine an over-running gear and a clutch mechanism drives a shaft connected to the single rear wheel. From the front of the engine another shaft runs forward between the seats to a small gear selector box. The pilot can connect and disconnect the engine to the propellers (two of them rotate in opposite directions to eliminate torque), or drive the rotors preparatory to the take-off.

The small steel-tube cabin fuselage seats two persons side by side and is somewhat shorter than that of a corresponding airplane. There is no trace of wings and the control surfaces are reduced to fin and stabilizer, assembled into a single cellular unit, and a small auxiliary rudder.

On the floor of the cabin are pedals through which the pilot can control the two fully steerable and brakeable front wheels. From the cabin roof hangs the control stick through which the rotor is tilted and which has a motorcycle-type grip-throttle connected with the engine.

Tentative specifications give the ship a landing speed of zero miles per hour, top speeds of 115 miles per hour in the air and 25 miles per hour on the highway. It is to have storage dimensions of 24 x 7 x 8 and a gross weight of 1,350 pounds.

—Aviation.

CHASSISLESS AUTOS

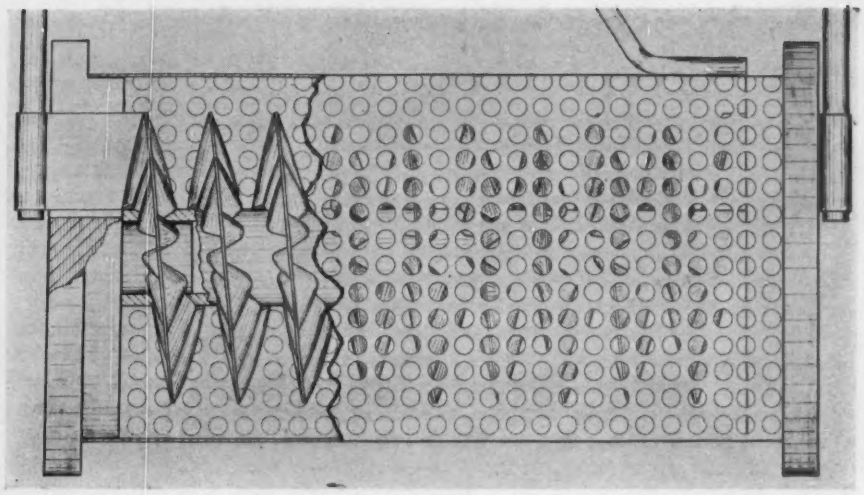
TO evolve a revolutionary or even a marked change in manufacturing technique in these days is a feat of no mean proportions. Yet the introduction of the chassisless automobiles actually brought about the first fundamental change in passenger car assembly practice in many years.

This type of car eliminates the frame and chassis assembly and requires an entirely different kind of final assembly. In fact, there is only one assembly line as we know it ordinarily, and most of the running gear installation is made with the body suspended from an overhead monorail rather than on a floor conveyor.

The unique features of the assembly of these cars are the various positions in which the assembly is made. The engine assembly of one make, for example, is handled in three different positions to facilitate the work: straight up-and-down for piston and upper bearings, top down for crankshaft installation, and normal position for the final touches and attachment of clutch and transmission.

A brief excursion through a plant in which these cars are manufactured would serve as a reasonable perspective of an entirely new idea in motor car manufacture. Only a personal visit would make one appreciate the time and labor and innite detail evident in every department, all of which sets the chassisless car is in a class all its own. At the present time there are three domestic manufacturers in this field.

—Automotive Industries.



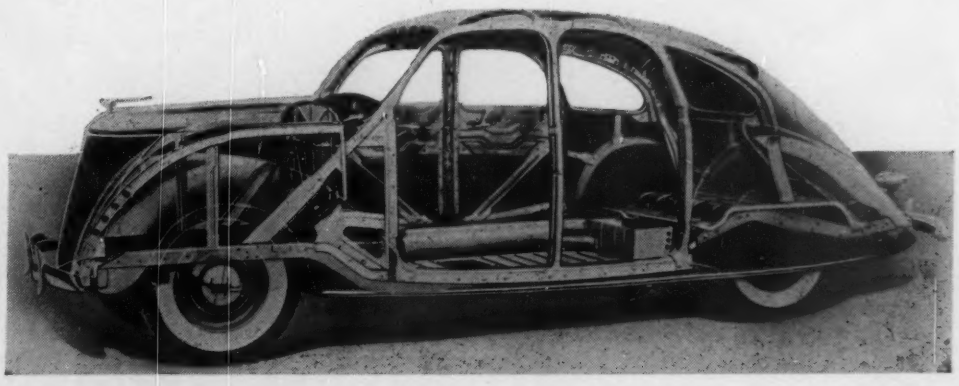
GRID GLOW TUBE

THE new Westinghouse KU-676 grid glow tube has several important features incorporated in its design. Two new features in gaseous-discharge tubes are a built-in time delay for protection of the cathode when starting the tube and a new cathode design resulting in a high ratio of crest-to-average current rating. High ratios of crest-to-average current rating are especially important for welding timers, for six phase rectification, and for many similar applications.

The structure of the cathode is probably the outstanding improvement in the tube. The directly heated portion of the cathode is an edge-wound helix, which is closely surrounded by an indirectly-heated portion of perforated metal, coated only on the inside surface. The discharge is thus forced to pass through the perforations in the screen and then outward through the annular space between the screen and the first radiation shield. This construction has been developed with the object of electrostatically shielding the active surfaces of the cathode to such an extent that they are not subject to high field strengths and are fully protected from excessive positive ion bombardment.

The current rating of the KU-676 tube is 6.4 amperes average and 7.5 amperes crest, while the cathode heating energy required is only 55 watts.

—Communications and Broadcast Engineering.



RESEARCH IN REVIEW

COURSE XVI — Aeronautical Engineering

THE magnetic compass is one of the most important aircraft instruments. Successful completion of a flight with either good or bad visibility often depends upon a good compass. Despite the fact that radio and gyroscopic instruments can replace the compass under certain conditions, a compass is required equipment on all airplanes for cross country flying.

On an east-west course, the compass is a satisfactory instrument. If the pilot decides to fly toward the north, however, the compass exhibits a very embarrasing trait called the "northerly turning error". That is, if the airplane makes a turn from north, either because of an air bump or operation of the controls, the compass usually indicates a turn in the wrong direction. This behaviour is due to the fact that the magnetic system of the compass is pendulous and consequently swings away from the horizontal plane under the action of centrifugal force in a turn. When the card is tilted about a north-south axis, the vertical component of the earth's field is able to move the north end of the compass card away from its proper direction. Unfortunately this motion is always in the direction of the airplane turn so that the pilot will see either a reduced turn or a turn in the wrong direction. The most successful remedy for this difficulty has been to supplement the compass by gyroscopic instruments such as the Pioneer Turn Indicator and the Sperry Directional Gyro. However, the theory already developed by many investigators shows the possibility of reducing the northerly turning error by modifications to the compass itself.

The compass problem is being studied in the Aeronautical Instrument Laboratory at Technology under the direction of Professor C. S. Draper. Messrs. J. L. Witherstine and J. B. Kendrick are assisting in this work.

A compass analyser has been developed for measuring the fundamental properties of a compass by means of controllable magnetic fields. With the analyser, a compass can, in effect, be taken many miles out in space to a region free from the earth's field. Under this condition, the inertial properties of the card can be studied without the complication of magnetic forces. It is also possible to subject the compass to magnetic field changes similar to those which occur in an actual airplane maneuver. Data taken in the laboratory have been used to predict theoretically the behaviour of a compass in an airplane. Motion pictures taken in flight have shown that the theory is correct to a reasonably good approximation. On the basis of these results a modified compass design is being developed in the hope that the northerly turning error can be greatly reduced in a practical instrument.

COURSE V — Chemistry

IN the Chemistry Department, certain phases of an investigation of the ultra-violet absorption spectra of the hydrocarbons, cyclopropane and propylene, and of the Raman spectrum of cyclopropane, have been completed recently. The work was undertaken jointly by Professor Avery A. Ashdown, '24, Louis Harris, '20, and Robert T. Armstrong, '31. According to the original plans it was hoped to find a way for changing cyclopropane into its isomer, propylene, by a photo-chemical reaction, instead of the well-known method of heating to a fairly high temperature.

To examine the possibilities of such a photo-chemical reaction required not only the preparation of very pure samples of cyclopropane and propylene, but as well, the determination of their absorption spectra. Improved methods for the preparations were found which gave products having a high degree of purity, which is indicated by their very narrow boiling point limits. The range for cyclopropane, the more interesting of the two compounds, was within a hundredth of a degree centrigrade, while that for propylene was somewhat greater, being about four hundredths of a degree.

The absorption spectrum measurements of cyclopropane, made on a quartz spectrograph, showed it to be a very transparent compound, transmitting light down to wave lengths of 1950 Angström units. Propylene differs markedly in that it begins to absorb light at 2400 Angström units and its absorption increases rapidly as shorter wave lengths are employed.

By making quantitative measurements of the ultra-violet absorption of pure samples of each of these two compounds, it was possible to detect quantities of propylene as low as 0.03 mol per cent in cyclopropane. It was clear, furthermore, that analyses of mixtures of these two hydrocarbons could be made very accurately by determining their absorption at a wave length of light of 2000 Angström units. By using data thus obtained, it would be possible to follow very precisely the kinetics of the isomeric change of cyclopropane into propylene.

However, at this point in the investigation, a more interesting procedure presented itself. The very high transmission of cyclopropane suggested studying its Raman spectrum using radiation in the near ultra-violet or, to be precise, by using the 2536 line of mercury for exciting the Raman spectrum. The results of this study confirmed what had been done earlier in the visible region and gave rise, to many new Raman lines for cyclopropane which have proved to be very useful in new calculations of the symmetry of this molecule and have given further insight into its structure.

In the course of this work, it was rather surprising to discover a mercury-sensitized photo-polymerization of cyclopropane. The product formed from the gaseous cyclopropane was a clear, water-white liquid having a boiling point of about 300° C.

COURSE VI — Electrical Engineering

NETWORK synthesis, or network design to meet specified requirements, has been the subject of considerable research in the electrical engineering field in recent years. Methods have been developed whereby networks may be designed to meet certain definite specifications, provided these specifications are given in the form of algebraic expressions meeting rather rigorous conditions.

Mr. Carl Neitzert, member of the Electrical Engineering staff, has, as a doctor's thesis, developed a method of network synthesis which has, to some extent, been freed from the necessary rigor of most previous methods. The specifications may be given in the form of curves, obtained from experimental data; and, if the solution is possible, any desired tolerance within the accuracy of the original data may be met.

The method confines itself to the particular frequency range of interest, and is not concerned with what happens outside this range. This, together with the fact that it consists of a series of approximations, each step of which gives a close approximation to the desired curve, with, of course, a more complicated network, allows all attention to be concentrated

on the frequency range of interest and gives the designer considerable choice between accuracy and economy.

One of the outstanding features of the method is that it is capable of very closely approximating certain reactance frequency curves that cannot be exactly represented by realizable networks. For example, the curve $Z = \sqrt{a^2 - f^2}$, which cannot be represented as a true impedance, may be approximated as closely as desired for values of frequency above $f = a$.

The method, while dealing specifically with simple two terminal networks, has been extended to cover several more complicated circuits and gives promise of considerable more application.

COURSE XI — Engineering Construction

IN Course XI studies of the theory of clarification of water and sewage by sedimentation have been continued during the past year by Professor Camp. It has been found that flocculation is always present to some extent in the suspensions dealt with by the sanitary engineers, and its effect is to increase the removal over that which would be obtained with suspensions of discrete particles. Efforts are being made to measure the effect of flocculation on removal for different types of suspensions.

COURSE III — Mining and Metallurgy

AN extended investigation is being carried out at present on high fired crystalline glazes. This type of glaze usually contains a considerable amount of zinc oxide or titanium oxide which crystallize out of the glaze melt on cooling and produce a considerable variety of large crystals, very much like frost crystals on a window pane. By adding to the glaze various coloring oxides, such as cobalt, very interesting effects can be produced.

Another investigation concerns the colors produced by spinels when used in glazes. The spinels have strong coloring power and are comparatively insoluble in the glazes, and for this reason comprise many of our more important ceramic colors. This work is an attempt to systemize the rather haphazard production of ceramic colors.

Considerable work is now being carried out to study the plastic flow of ceramic bodies at elevated temperatures. It is found that the flow characteristics of heated porcelain are very similar to those of a plastic metal like copper. A study of this flow is of great importance, as it is encountered in the firing of almost all vitreous wares, where it produces a certain degree of distortion which is undesirable. Again, in the construction of high temperature furnaces, the load that a certain refractory can withstand depends on the flow characteristics of this particular material. It is hoped to determine the exact laws of flow, which will greatly reduce the number of tests required to give a complete picture of the situation. Research on the translucency of porcelain is being carried out, a subject on which previously no scientific work has been done. Therefore, in this study, the light transmitted by porcelain is carefully analyzed to give the complete specifications. Some very interesting conclusions have been reached regarding the cause of translucency and the influence of various feldspars on this factor.

Work is being pursued on the study of particle sizes, especially in clays. There is, at present, no very satisfactory way of measuring particle sizes below one-half micron. Various methods are being attempted to develop a satisfactory standard method for measuring the whole range of particle sizes down into the colloidal range.

COURSE I — Civil Engineering

THE 115-foot model of the Cape Cod Canal, largest hydraulic model in the world, is now under investigation for the Corps of Engineers, U. S. Army. This research is being carried out under the direction of Professor K. C. Reynolds. It represents 13½ miles of nature, the tides in Cape Cod and Buzzards Bay being reproduced with an accuracy of 1/100 inch by means of an ingenious device developed by Professor Hazen of the Department of Electrical Engineering. Water levels in the canal are determined electrically with the same accuracy. Many valuable data are being obtained as to water levels, velocities, and eddy formations in anticipation of the construction of the wider canal. Other research includes the study of the transportation of the bed-load of streams, of flow over a dam with piers, of flow over a side-channel spillway, and of the drag of fish nets.

Recent research in the field of earthquakes has been concentrated largely upon two important problems. These are: (1) the behavior of elevated water tanks when subjected to earthquake motions; and (2) the development of a quake-resistant design for such structures. Studies of the behavior of tanks subjected to actual earthquake motion as recorded March 10, 1933, in Los Angeles, indicate that the present design methods are not at all adequate and do not rest on a rational basis. Concerning the new design it can be said that the engineering problem is already solved. However, there is still an economic question to be considered.

A problem of great economic importance in the field of hydraulics is the rate at which pipes deteriorate with respect

Arthur C. Ruge is shown above with the new earthquake machine. This machine can duplicate the motion of earthquakes directly from seismographic records.

RESEARCH IN REVIEW

(*Continued on page 99*)

to their possible carrying capacities. Due to corrosion of the metal, impairment of protective coatings, and the deposition of organic or inorganic material on their walls, pipes gradually increase in surface roughness and decrease in effective diameter. The result is increased frictional resistance and decrease in carrying capacity. Within the last year a large amount of experimental data have become available for coated cast-iron pipes ranging in diameter from four to sixty inches, and in age from one to seventy years. These data are being analyzed by M. S. Carter under the direction of Professor Russell. Definite trends in the rate of deterioration are being established and it is hoped that reliable data for design will be made available.

For Soil Mechanics research a new type of consolidation device, in which friction on the sides of the sample is eliminated, has been developed and is now being tested. A study of consolidation and permeability, attempting to determine an improved method of correlating experimental results with the basic theoretical relationships is under way. The design of a new shear-testing machine of the strain-application type is completed and its construction is being started. Extensive studies and computations of stabilities of slopes are being carried on for the purpose of eliminating the very lengthy methods now necessary for the solution of stability problems. On a new model retaining wall, based on a mechanical analogy using steel rods for backfill and thus eliminating side-wall friction, investigations are being made of the effect on the yield of the wall of pressure, obliquity of pressure, and line of thrust, for the active and the passive cases.

Four Army Engineer Officers are finishing individual researches concerned with the use of coarse or fine cements. One has investigated the effect on strength, another the effect on durability by freeze and thaw tests, a third has sought to find a relation between absorption and density, the fourth has investigated the relation between absorption and the mix used. All have reported the possibility of reducing the amount of cement used if finer cements are employed. Another graduate student is investigating the deposition of concrete under water, using model tremies and bottom-drop buckets. The tank used has a glass side so that photographs can be taken of underwater conditions. Undergraduate theses include freeze tests to determine the cause of surface scaling in concrete pavement, an investigation of the effect of surface finishing of pavement on resistance to scaling, the effect of freezing temperatures at the top surface of concrete while the protected under-surface is in contact with water.

Mr. A. J. Bone has just completed an analysis of annual road costs and motor vehicle tax contributions for state highways in Worcester County, Massachusetts. This analysis illustrates a practical method for obtaining annual road costs, which include interest on investments, annual maintenance of all kinds, and depreciation. The sum of these costs, when available for every highway section, furnishes a tangible basis for justifying highway improvements and distributing highway revenue. The results are shown graphically on a flow sheet of annual road costs and tax contributions which is the first of its kind to be prepared.

BAKELITE

(*Continued from page 91*)

ornaments, and in many places where metals once served, Bakelite is entering the field. The miscellaneous uses of the substance cover ranges such as fountain pens, umbrella heads, beads, armatures, radio dials, cigarette holders, ornamental boxes, and billiard balls. A billiard ball can be made with a particular composition of the resin, so that if dropped two stories, the ball will bounce back one, indicating elasticity decidedly higher than that of ivory. When mixed with graphite, Bakelite forms a self-lubricating bearing; going to the other extreme, when mixed with abrasives, it forms as good grindstone as has ever been made.

Dr. Leo Hendrick Baekeland was born in the ancient Flemish city of Ghent in 1863, but came to America in 1889 as an active research chemist. Although Bakelite may be considered the greatest of his triumphs, Baekeland hascontributed many other discoveries to the world, among which is "Velox" developing paper. In 1893, in partnership with Leonard Jacobi he began to manufacture "Velox." The business prospered. George Eastman wanted the process, and he bought it. In 1906, not long after his success with photographic paper, Dr. Baekeland set up a private laboratory in Yonkers, New York, where he concentrated on his life hobby—the discovery of a synthetic resin for which the electrical world, seeking a new nonconductor, was waiting. Little did he dream that three years later, in 1909, he would have completed the discovery of not only a nonconductor of electricity, but also of a substance that would create an entirely new field in science and industry—Bakelite.

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CYANAMID

(*Continued from page 88*)

Practically simultaneously with the development of the Cyanamid process came into existence the so-called Arc process of fixation in which air is burned to nitric oxide in the electric arc. This process received its largest development in Norway although examples on a much smaller scale appeared in France, Austria, Switzerland, and the United States. With the exception of the Norwegian plant, no further development after the original construction took place in any of these units and most of them have been closed down and abandoned. The process did not survive competition.

The direct process of combining nitrogen with hydrogen to form ammonia was a somewhat later development, the first commercial unit being erected in Germany during the latter years of the war. One large German unit did contribute to the fixed nitrogen supply of Germany before the peace treaty was signed, but no successful applications were made of this process outside of that country until well after the war was over. Since that day the Synthetic Ammonia plants have been built by a number of countries under various engineers, and today they represent a producing capacity of three times that of Cyanamid. It is possible to produce hydrogen by the electrolysis of water, and given cheap power such as found in many localities in the world, a plant of this type forms a very satisfactory operating unit. More than half dozen such are located throughout the world, their power consumption averaging about 10 percent higher than that of the Cyanamid process. With ammonia as an end product such plants require only water as a raw material. The capital cost of the plant is many times that of a Cyanamid plant and interest and depreciation offset the costs of raw materials of the Cyanamid process. Most of these synthetic ammonia plants, however, use coal as a raw material in the production of hydrogen, converting the coal to water gas and oxidizing carbon monoxide of the latter to carbon dioxide by means of steam and a catalyst. The carbon dioxide is washed out by water under pressure. In general such plants involve an even larger capital cost than for the electrolytic process, but substitute fuel for electric energy to a very large extent.

The problem of nitrogen fixation has lost much of its purely commercial aspect. It has become a keystone of national defense and fixation plants of one or the other processes have multiplied enormously, not from economic pressure but rather from military preparedness and national self-sufficiency. In these depressed times the consumption of nitrogen is probably not over two million tons per year and has never exceeded 2½ million tons, for all purposes. The productive capacity of synthetic plants alone scattered throughout the world is in excess of 3½ million tons to which can be added additional supplies of fixed nitrogen from the coke ovens and the nitrate fields of Chile. In consequence most of the nitrogen plants of the world are operating at greatly reduced capacities.

Recent units have been constructed in Russia, both Cyanamid and Synthetic Ammonia and similarly in Japan and Korea. Where military necessity is the principal deciding

(*Continued on page 102*)

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CYANAMID

(*Continued from page 101*)

factor the Synthetic process is preferred since its principal product is ammonia readily oxidized to nitric acid and from thence into explosives. Where agriculture exerts a predominating influence Cyanamid is preferred since the first product of manufacture carrying nitrogen is directly available for fertilizer. Electric power is an absolute necessity in the Cyanamid process and where unavailable at low prices the water-gas synthetic-ammonia process receives preference.

The competitive position of the two processes, it can be readily seen, is one of a specific study of local conditions and cannot be exactly stated in general terms. The existence of both Cyanamid and Synthetic-Ammonia plants in Germany selling their products largely in agriculture and at competitive prices, is an indication that there is comparatively little difference in costs of manufacture under reasonably favorable conditions to both processes. The same is true in Norway where Cyanamid and Synthetic processes operate competitively.

Italy possesses about an equal number of Cyanamid and Synthetic plants and has imported up until recent times considerable quantities of Cyanamid.

Agriculturally there is practically no difference in the crop returns from the products of the two processes. Cyanamid is a basic material carrying the equivalent of about 65 per cent of lime. The advantage of such basic material in modern agriculture has been so pronounced that it has forced the Synthetic processes to convert their product largely into nitrate of lime, although originally most of them started with sulphate of ammonia as their principal fertilizer product. It probably requires a little more care in the use of Cyanamid to avoid crop damage than it does with the use of calcium nitrate, but once instructed in the simple precautions it is difficult to find any widespread difference between the agricultural results from Cyanamid and from nitrate of lime. In general, Cyanamid has proved itself superior on the average to sulphate of ammonia. Cyanamid itself also finds large application abroad as a combined weed killer and fertilizer material, such use consuming approximately one-third of the German output from four operating plants.

It is possible to convert Cyanamid into ammonia and such has been practiced for many years. The operation is a simple one of hydrolysis conducted under pressure in autoclaves. In general, however, such conversion may not be competitive with the more direct process of producing ammonia from nitrogen and hydrogen. Cyanamid itself also forms a basic material for the production of a number of derivatives, cyanides, urea, guanidine, dicyandiamid, and the like, and from which many technical and pharmaceutical products are produced, but the consumption for these purposes is small compared to agriculture.

In this brief sketch it is seen that the nitrogen industry is one of the world's large chemical units in which there are many hundreds of millions of dollars invested, and at prevailing prices of producing products of a value of well above 200 million dollars per year. Complete statistics are not easy to obtain since many of the plants are built under Government subsidy, even under Government auspices, and form an important part of the defensive programs of the country. It is difficult to obtain true figures for either capacity or output of many such plants and I may possibly have erred somewhat on the conservative side on the figures I have given above which represent minimum authenticated capacities and outputs. Construction is still progressing in this industry in spite of the surplus productive capacity, many of the independent countries still adding to existing capacity and those unprovided giving serious consideration to entering the field. The incentive is largely military, but often dressed in the garb of agriculture.

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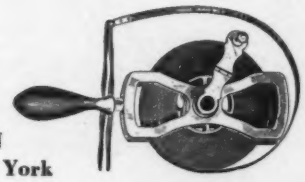

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EDITORIALS

(*Continued from page 95*)

and commercial interests to promote the cause of dirigibles. They point to the various advantages of Zeppelins. It is interesting to note that no paying passenger has ever lost his life in a Zeppelin and the record of the *Graf Zeppelin* is amazing. It has made more than fifty round trip flights to South America and has flown around the world. It took the *Graf Zeppelin* less than three days to fly from Tokio to San Francisco, and the present flying boat service of Pan American Airways takes six days for the Pacific crossing because of the many necessary stops. Even then the planes are heavily loaded with fuel and their payload is small. The *Hindenburg* is faster than the *Graf Zeppelin* and should be able to make the Pacific crossing in considerably less time.

Commander Rosendahl points to the large amount of research that has been carried on in connection with airplane development, while little research has gone on in Zeppelin development except at the Zeppelin Works in Friedrichsafen.

One of the main faults with Zeppelins, and what caused the crashes of the *Macon*, *Akron*, and *Shenandoah*, was that strong vertical currents of air tend to break the ship in half. Apparently it is important for a dirigible to avoid a thunderstorm or squall where these vertical currents are strong. It has been claimed that the commander of the *Akron* was not well aware of the importance of avoiding a thunderstorm and flew right into one. When the *Macon* and *Akron* crashed, Commander Rosendahl, who knows more about dirigibles than anybody in this country, was away serving a term at sea duty on a battleship. If Commander Rosendahl had been on the *Akron* and the *Macon* it is quite possible that we would have both of these dirigibles today.

It would be unwise for us to commit ourselves to the superiority of the dirigible or the airplane, but it is unquestionable that the dirigible has its advantages and that they deserve more attention from both a military and commercial viewpoint then they have received in this country in the past few years.

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FUTURE IN FOOD

(*Continued from page 82*)

ism performs nearly two million milkings a year under conditions simulating those of a hospital operating room, yet does it at a cost per milking lower than that on many farms. This Rotolactor, located at the Walker-Gordon Laboratories farm near Princeton, New Jersey, is worth going many miles to see and is open for inspection.

There are many more examples in the food industries which could be mentioned, thousands less spectacular but equally important from the standpoint of efficiency, economy, utility, and safety, but space forbids their discussion.

Should the technically trained scientific graduate say that no further developments are possible in the allied food fields, when each year the American people spend 28 per cent of their annual income for foods and food products? Should he feel that he could not use his talents in this type of industry to advantage, whatever those talents may be? Some of the 1936 graduates will demonstrate in the years to come that there *are* futures in foods, if one seeks them.

YOUNG CHEMIST

(*Continued from page 93*)

chemist, associate chemist, chemist, senior chemist, principal chemist, and head chemist, the latter position paying about $7,500 per year. It must be said, however, that in the last five years or so, promotions have been rare. The few head chemists in the government service are outstanding in their profession; the one in the Public Health Service, for instance, is a Willard Gibbs medallist. There are the decided advantages of steady employment, opportunity for graduate study, annual leave with pay, sick leave, and provision for retirement. It is thus not difficult to see why many chemists seek to make their careers in the government service.

The writer will now venture a few words of advice, offered in the friendliest and most cordial spirit, to those students who contemplate taking the examination. Concentrate on one or two of the optional subjects and do not take the examination in all four of them. A very high grade in the examination in general chemistry and one of the optionals is infinitely preferable to a merely passing grade in all four of the optional subjects. The choice appointments, those offering the finest opportunities, are given to the men at the top of the list. They are the appointments worth getting and worth striving for. Then, when you have received your appointment allow free play to all your intelligence, industry, diligence, resourcefulness, personality—and luck.

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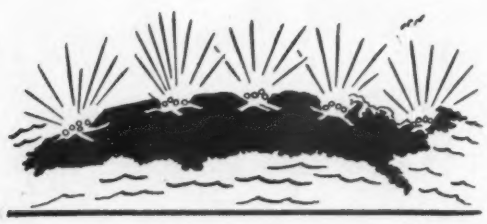

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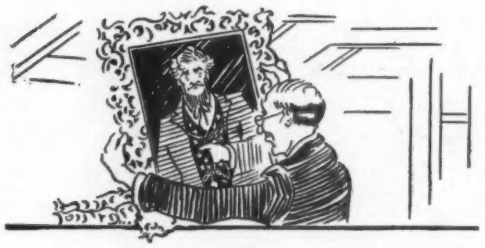
THE mellow, golden-orange glow of sodium lighting is springing up all across the continent. The latest installation, the largest in the United States, is located in the state of Washington. Here sixty-six 10,000-lumen General Electric units line almost three miles of the four-lane Pacific highway between Tacoma and Fort Lewis.

Less than three years ago the sodium lamp made its first American appearance on a highway near Schenectady. Today the largest installation is on the Pacific coast, and the second-largest is at Lynn, Mass., on the Atlantic. In between, highways, bridges, traffic circles, and underpasses are being lighted for safety with these new luminaires, and G-E sodium lighting units have been installed in Canada, Hawaii, India, Spain, South Africa, Dutch East Indies, and Brazil.



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Not long ago, a portable G-E X-Ray Corporation unit disclosed a valuable canvas by the seventeenth-century artist, Goya, concealed under an apparently worthless picture. More recently a New Orleans painter and art expert has used the x-ray to discover a genuine da Vinci signature beneath layers of paint applied by a later and less-capable artist. A sister painting to the newly found da Vinci recently sold for a quarter of a million dollars.

The x-ray does more than discover lost Old Masters; it tells how the great artists of the past worked. A series of radiographs can disclose the full story of their brushwork from the first rough sketch to the last correction and afterthought. The art student of today, by an intelligent use of the x-ray, is in a position to take lessons from the geniuses of the past.

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